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PROCEEDINGS OF THE DOD-WIDE TECHNICAL LABORATORY DIRECTORS CONF--ETC(U)
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PROCEEDINGS OF THE FIRST DOD-WIDE
TECHNICAL LABORATORY DIRECTORS CONFERENCE

Sponsored by the Office of the Under Secretary of Defense for Research and Engineering

National Bureau of Standards
Gaithersburg, Maryland

23-24 July 1978

PROCEEDINGS OF THE FIRST DOD-WIDE TECHNICAL LABORATORY DIRECTORS CONFERENCE (1st)

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OFFICE OF THE UNDER SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

RESEARCH AND
ENGINEERING

MEMORANDUM FOR CONFERENCE PARTICIPANTS

The first meeting of the more than seventy Technical Directors of Department of Defense in-house laboratories and the staff of the Office of the Deputy Under secretary for Defense for Research and Advanced Technology, was held July 24 and 25, 1978. The Conference objective was to initiate a greater participation of Technical Directors in formulating the DoD Science and Technology Program Strategy. An equally important goal was to encourage and strengthen working interactions among Technical Directors throughout the Department of Defense.

The conference was organized and chaired by Dr. Ruth M. Davis, Deputy Under Secretary for Research and Engineering (Research and Advanced Technology). The meeting was strongly supported by Dr. William J. Perry, Under Secretary of Defense for Research and Engineering, and the Assistant Secretaries responsible for research in the three Military Departments.

A highlight of the meeting was remarks by the Honorable Richard H. Ichord, Chairman of the House Armed Services Subcommittee on Research and Development. He was the dinner speaker on the evening of July 24. A summary of his remarks was reported in the September-October 1978 issue of the Army Research and Development Magazine, and is appended to these proceedings.

These proceedings are primarily based on a transcript of remarks by the various speakers and workshop chairmen, occasionally augmented by vuegraphs and written summaries. The success of the meeting is in large measure attributable to the enthusiastic participation of the Technical Directors and to the invited speakers.

Appreciation is also expressed to the Air Force Office of Scientific Research for providing logistic help with the conference and the National Bureau of Standards for permitting us to hold the meeting there and offering expert staff support. Last, and certainly not least, I would like to thank the secretaries of the OUSDRE (R&AT), particularly Ms. Sandia Giglio, whose simple task was just to make sure nothing was left undone.

George Gamota
George Gamota
Assistant for Research to the
Deputy Under Secretary of Defense
(Research and Advanced Technology)

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PLENARY SESSION

DR. ERNEST AMBLER

I am really very delighted that you chose the Bureau of Standards for the first meeting of all the Technical Directors of Defense research Laboratories. It is great to see so many familiar faces. Ruth has mentioned the fact that she and Dave Mann are alumni of the Bureau of Standards, and I am delighted to see my colleague, Allen Berman, from the Naval Research Laboratory, and many others.

The fact that we know so many of you personally is simply evidence of the long and successful technical cooperation between the Bureau and many parts of the Defense Department. The Defense Department characteristically uses a very wide range of Bureau competences.

The $11 million of research currently sponsored in total annually by the various parts of DoD covers areas such as ionizing radiation, lasers, microwaves and MM-waves, antennas, materials, corrosion, NDE, cryogenics, fire research, building research, semi-conductor technology and computers.

In very broad terms, NBS works with you in three major areas. First, we are responsible for the national measurement base. This base is of vital importance to those defense-related activities that depend on precision measurement. For example, our people at Boulder are responsible for the national standard of frequency, they provide the second to the Naval Observatory, and they broadcast time and frequency information from radio stations in Colorado and Hawaii. As you know, many military specs call for measurement traceability to NBS, and we work with both military and contractor labs to meet these needs.

You who work at the forefront of science and technology know that measurement requirements are far from static. The swing to automatic test equipment, and the coming wave of microprocessors that are changing the nature of both instruments and sensors, are altering the types of service NBS must provide.

Second, we also provide support for your advanced research and developmen efforts. This support might take the form of standard reference data, development of a new measurement methodology, a theoretical study, or measurement of parameters in areas where we have special expertise. An example is the work that we have done for the Advanced High Power Laser program at ARPA and the major weapons laboratories. This work includes high resolution spectroscopy of transient electronically excited laser molecules such as the rare gas oxides and halides and Group II metal dimers. We have also made significant contributions to the theory of the structure and radiative characteristics of excimer systems. This work has had significant impact on the modeling of high-powered gas laser systems.

The third area of interaction falls in the area of test methods and measurements. While we are not in the business of specification writing, we do work to provide the measurement methods upon which many specs depend. Our work helps you reduce costs and assure reliability.

A prime example is in electronic technology. For some years DoD has sponsored work at NBS aimed at improving electronic reliability and economy in procurement and applications. This work is appropriate for NBS. We have a unique interest in and ability to solve measurement problems related to process control, quality assurance and procurement. We do not compete with industry or DoD in development of products, processes, standards, and specifications. We do provide the measurement tools and data required to support all of these functions. An important element in this program is the excellent working relationships we have with the electronics industry. They see us as a credible, independent third party whose only role is to help them make a better product.

This work is having a major impact on reliability and cost reduction. For example, data supplied by industry indicates that:

- The five industrial standards that have evolved from our work on resistivity measurements have saved over $30 million in test and procurement costs;
- Our work on ultrasonic bonding has increased yields from 2 to 35 times, has avoided 3- to 6-month delays in DoD programs, and has made possible large military hybrid systems with over 500 bonds each;
- Our hermeticity work has resolved disputes and a supplier disqualification for purchase of 45 million devices.

I could go on with more examples, but I think I've made my point that this program is having a major impact on the procurement and use of military electronics.

We also have a program of non-destructive evaluation that has direct bearing on assuring performance. We initiated this program a few years ago to improve the reliability of NDE measurements. The need to do so is quite compelling. The Air Force and the Army asked us to look at variability of the aluminum reference blocks used to calibrate ultrasonic inspection equipment. We found an average variability of 40 percent--large enough so one group might accept an aluminum structure welded on an aircraft while another group would reject it. To help correct this situation we now offer a calibration service good to 7 percent, and we aim to reach 3 percent in the future.

We also are working in other major areas of NDE, such as radiography, magnetic inspection, visual assessment, penetrants, and the like. One project of particular interest is that on neutron radiographic detection of aircraft corrosion. This work, sponsored by the Naval Air Development Center, grows out of our work to develop standards for

this technique. We view this NDE program as having the potential for making significant contributions to safety, improved performance and quality assurance.

I mentioned industrial relations before. There is another project in which close ties to industry are an important factor. That project is in the field of integrated computer-aided manufacturing.

The Air Force feels that computer-aided manufacturing will grow rapidly. They also feel that the benefits--to both Defense Department and to the civilian economy--will be maximized by an integrated approach. Thus, the Air Force, in its ICAM Program, seeks to provide unified direction for American industry. They also intend to shorten the time needed for developing and incorporating compatibility and standardized techniques that can be used industry-wide. We will establish guidelines for the selection of robots, computer languages, and control systems, and provide technical support in such areas as programming and sensor technology.

I think this is an extremely important program, for it could well pave the way for the orderly integration of robotics into American industry.

So far, I've described three broad areas in which NBS interacts with DoD. Obviously, your needs influence and shape our programs. And I think I've demonstrated this with examples in various areas. There are, of course, numerous other factors that take us in particular directions, in other words affect our planning. For example, new legislation has had a substantial impact over the past 10 years but, in the time remaining, I can only discuss one thing, and I have chosen major concerns of the Administration, that impact us through DoC.

The President has expressed his concern over the strength of the economy and the rate of innovation in the civilian sector.

In response to this concern, the President has called for a Domestic Policy Review of Industrial Innovation. This will be directed by Jordan Baruch, Assistant Secretary of DoC for S&T. This review is based upon a recognition that actions of the Federal Government have significant impact upon most firms' abilities and decisions to innovate. Through careful, systematic consideration and precise formulation of specific policies and programs, the Federal Government may be able to influence the future rate and direction of industrial innovation in a way that will provide positive benefits to the economy and to society. Five task forces have been created to conduct this review. They are in the areas of:

- Economic Policy and International and Trade Policy
- Environmental, Health, and Safety Regulations

- Federal Direct Support for Research and Development and Procurement Policy
- Patent and Information Policy
- Regulation of Industry Structure and Competition

Membership for the five task forces will be drawn from more than 30 Federal departments and agencies. (Secretary Brown is a member of the steering committee.) These task forces will be assisted in their work by an advisory committee for academia, labor, the private industrail sector and public interest groups. The Domestic Policy Review will proceed in two phases--a public information gathering phase followed by an option development and assessment phase. The output will be a set of specific, carefully analyzed options for consideration by the President. Each option will include an implementation plan and an evaluation plan so that significant impacts of adopted options can be assessed. NBS will assist in this implementation and evaluation planning.

It is clear that the research and the needs of the Department of Defense have a major impact on civilian technology. Many of the processes and developments that are driven by defense procurements find their way to commercial applications. To help promote a healthy economy, there is a fundamental difference, in that the non-military side of Government is not a major purchaser of products and systems. The leverage points are different, and they need to be defined and exploited.

The President is also concerned about the amount of quality of basic research in the United States. As the Director of a Federal laboratory, my immediate concern is the level of scientific ability at NBS.

I'm sure that all of you have felt, as we have, the impact of taking on new assignments in a period of fixed or declining budgets and personnel ceilings. In such a situation, one of the most challenging and important tasks is that of maintaining scientific vitality.

We have taken very positive steps to preserve and strengthen our own scientific muscle. With support of our NAS Evaluation Panels and Statutory Visiting Committee, we have demonstrated to the Department of Commerce and OMB the need to establish a separate, top-priority program dedicated to maintaining the vigor of this institution. There is a $2 million line item in the 1979 budget for this purpose, and we expect in 5 years that such funds will reach 15 percent of our total appropriation.

With these funds we will establish areas of excellence that will strengthen NBS and put us in position to discharge our long-range responsibilities. We expect the areas of excellence to have long lifetimes, but to be adaptable to change. In selecting areas to be strengthened, we must be aware of external needs and trends, and we must factor in our long-term program projections.

Some of the areas we are considering are:

- Laser Chemistry--The ability to drive chemical reactions by laser radiation is an exciting new field. Capabilities in this area might have bearing on such work as isotope separation, isomer production, and production of molecules from highly energetic states that cannot be achieved by thermal processes.
- Competence in surface science will bear directly on understanding catalysis, and catalysis is involved in the production of billions of dollars worth of goods every year. Surface science is also important in VLSI, for the production and performance of such circuits depends to a major extent on the physical and chemical properties of surfaces.
- We also plan to build competence in materials durability, including basic research on corrosion, fracture, and wear. Expertise in this area may help minimize the economic and social consequences of materials failures.

I hope you have found these remarks useful. I certainly feel that you have a most interesting conference arranged in the next 2 days. The session on Tuesday afternoon when you will survey the output of the workshops is one that we would very much like to attend and I hope you will permit us to do so.

Again, I welcome you to NBS, and hope you enjoy your conference.

MR. PHILIP SMITH

I am very pleased to be here representing the President's Science Advisor, Frank Press. He had hoped to be here but there is a cabinet meeting this morning, and it is the first opportunity that the President is going to have to review some of the initiatives that may extend from a recent trip to China that Frank and a good many of the government R and D directors made. So he felt that he should spend time on that this morning.

I thought I would just try to briefly convey to you some of the President's interest in research and development; some of our feeling about research and development; some of our initiatives; and some of our views about the DoD R and D laboratory system and the leadership that you have in the Department of Defense.

The President and his Administration are deeply committed to research and development. Very early after he came into office, the President began to make inquiries into issues related to research and development. In his very first budget, he took special pains to try to identify and single out issues related to research, particularly basic research, and the relationship between the Federal laboratory system and the academic system.

About a year ago at this time, the President asked the Director of the Office of Management and Budget to remind the departments and agencies that basic research was important and to not let that drop into the cracks as all of the new methodologies such as zero-based budgeting came into play.

We have another similar kind of a reminder in the works right now that is going to be getting around. This time it is jointly signed by Mr. McIntyre and Frank Press, indicating, I think, the partnership between our office and the Office of Management and Budget in a great many science and technology policy issues.

Now a significant feature of this overall strategy is that we are trying very hard to insure that we have a broadly based R and D program. There was, as you know since a great many of you lived and suffered through it, a trend over a period of 10 or so years to kind of focus research perhaps in a very unnatural and also very unfortunate way in many of the mission agencies. It concentrated research to as great an extent on applied research, pushing basic work to agencies such as the National Science Foundation and the National Institutes of Health. Many of the things that had been done historically by mission agencies were cut back.

Our viewpoint is different. Our view is that there should be a broad base of basic research throughout all of the mission agencies, not just in the agencies such as the National Science Foundation. Thus in our budget strategy for 1979, we attempted to try to show this point of view by insuring that there was a buildup across the board. Thus there were new initiatives in agriculture, energy program and defense.

Now, there are a variety of other ways in which the President has expressed an interest in technology and in research. He has, as you know, a commitment to organizational reform, reorganization and governmental efficiency. There are many activities under way right now in which we are working in our office with the regulatory agencies to bring them together to try to get more consistency in their regulatory policy, to identify their common research needs, and to try to strengthen the basis for rule making. It is notable, I think, that you are all together perhaps for the first time. Let me tell you that you don't have to have 75 or 78 organizations to have a problem. The first meetings of the four environmental regulators to talk about their common needs -- they are OSHA, EPA, the Food and Drug Administration and the Consumer Products Safety Commission -- got started during this Administration, an initiative undertaken by Frank Press.

In organizational reform, however, I would tell you that the President and his reorganization project people are very mindful of the special role of research and development. Our office works very closely with the reorganization group, and will insure that there is no organization that will impair the base for research.

We have many initiatives under way. You have heard Ernie Ambler speak of the domestic policy review process. He mentioned one very important study. The reason of course, why industrial R and D is important to us is that although estimates vary, most people agree that something in the neighborhood of 30 to 40 percent of our growth in GNP over the last 30 years has stemmed from R and D and innovation. That is a very significant factor when one is considering economic strategies for the 1980s.

We have a number of simpler kinds of processes going on to look at other issues that bear on R and D. In the domestic policy review system, there is an attempt being made to try to provide some of the rigor and some of the discipline that has been customary in the national security and the defense structure for many years. They are domestic issues that need more analytical work and perhaps a little less politics and less rhetoric at the outset going in.

There are a lot of differences between how you handle some of these domestic problems and how you handle issues on the national security front so the analogy is only partly true.

We have a study under way of nonfuel minerals and materials, an area that many people think will be the energy crisis of the 1980s or the early 1990s. When this study is finished, we believe that it, along with the industrial R and D review, may lead to some policy considerations that will enable the President to make some very fundamental choices about ways we can change either our direct measures such as budgeting or our indirect support for R and D that comes through changes in our regulatory policies, antitrust policies, and so on.

We have a space policy study under way that some of you will have an interest in as it goes forward. The President has asked that we look not just at the civilian space policy but that we look at the sectoral relationships between the Defense and the civil space areas. Many of his advisors cautioned him that this is historically not the way we have approached the problem. We have tended to keep these areas separate. He responded by saying, as I look at it, I have to look at the interrelationships; and I want you to study them.

We also have an examination of aeronautical R and D under way, which is an effort involving both the Transportation Department and the Defense Department as well as NASA: and it too, may lead to the identification of some opportunities that would be particularly exciting. There is much discussion about the divergence of civil and military aviation needs and the basic research supporting these efforts. These perhaps are only temporal divergences relating to near term questions, not to some longer term issues. This also, of course, is a very exciting time to undertake an aeronautical review because of the dynamic changes that are taking place right now in the aviation industry itself and the opportunities for a rekindling of industrial R and D on the part of the aviation industry within the United States.

The historic role of the Defense Department and its laboratories in our total scheme of research and development in the United States is well-known, and I am not going to spend any time reviewing that at all. It probably is one of the two or three things that characterize our system of doing research and development in the United States that make it truly outstanding.

Over the last 10 or 15 years there have been a lot of issues that have kind of shoved R and D and laboratory managers around. Perhaps the approach has been based around very short-sighted policies. Flushed, perhaps with our success of getting to the moon and having other technological triumphs, we pushed too much to try to maximize on these technological capabilities for a wide range of civil sector and societal needs. We have seen over the last 10 years much pressure for applications, much pressure to take high technology in the low technology areas, to try to put the high technology to work on urban and civil problems such as transportation. I think we have learned a great deal

about the difference between some of the solutions that you use in a technological arena such as defense and the way you go about rebuilding a city.

Private sector spinoff from Federal missions, Federal laboratories, state and local government needs, are to be sure all important; and we continue to think they are important, but I think that they do not, in our minds, loom as large as perhaps they might have loomed a few years ago.

Further, you all know about the problem of defense funding and how over the last few years the decline of research and development has put the squeeze on the laboratory manager. You also know about a very insidious side effect of that problem which is the impact that this had on staffing and personnel.

Well, now, we think that the tide has turned to some extent, hopefully to a large extent, even though there is a tight budget. The President is very committed to balancing the budget or doing as much as can be done to keep the Federal budget from becoming a cause of inflation rather than contributing to inflation. And we will in the 1980 budget have a very tough budget review. Nonetheless, we think that the initiatives that are under way do stand a fairly good chance of having careful and considerate review, and thus we are hopeful that we are going to see a strong program in R and D in the years ahead.

The leadership in the Defense Department, we think, is perhaps one of the best leadership teams that has ever been in business from the standpoint of R and D; and I think that it is represented very well, of course, by the very strong team that is here this morning.

The principal job we have in your area of interest is to maintain our technological leadership. We can be under no illusion. There is a narrowing of the gap. Our adversaries are gaining in some respects upon us, and our future security must have a very strong technological base; and the DoD laboratory system is the very heart of that base. That is the primary challenge that you have.

Now, I don't know why it has taken so long to get all of the laboratory directors together. I was quite surprised, as was Frank Press, when Ruth told us that this apparently is the first meeting that you have all had. I can't say anything other than, why hasn't it happened before, and what a terribly good idea it is. We are going to look forward very much to the results of this conference and hope that there will be many more.

And all I can say is, in conclusion, that we wish you a great deal of success. We are very interested in your work, and we want to try to be as supportive as we can of the initiatives that are put forward by Secretary Brown, by Bill Perry and by the leadership team in the Defense Department.

Thank you.

DR. WILLIAM J. PERRY

It is very appropriate that I should follow Phil Smith in this discussion. We have been building in this last year a real community of scientific interests between the Defense Department and the President's Scientific Office. I have to especially say that I cannot but agree with Phil's observation about the brilliant leadership we have in Defense R and D these days.

As I look out at this group, I simply cannot resist paraphrasing a famous quotation from John Kennedy: and my paraphrasing of that would be that this is probably the greatest collection of scientific talent ever assembled in the government since John VonNeumann studied alone in his office.

This is really a unique opportunity for me to talk to a captive audience of more than 70 technical directors of our laboratories. I am going to take advantage of that opportunity to sort of give you a stream of consciousness about some of the problems that are on my mind these days.

In particular, we are just finishing pushing the FY 1979 R and D budget through the Congress, not quite finished yet, still a few problems here and there; and we are beginning to push the 1980 budget into the Executive Branch for review.

Now a fair amount of that discussion, and I guess you might say defense of the budget, involves the defense of individual programs. A more important part of it, though, is describing and defending an investment strategy for our research, development, and acquisition programs. I would like to share with you my perception, or the perceptions which guide my thinking in this area, and in fact which form the basis for the defense which I make for our programs.

In doing this, I would like to describe the nature of the competition which we face with the Soviet Union. It is very difficult, it is perhaps meaningless, to talk about the defense programs independent of the consideration of what it is or who it is you are defending against and what kind of a competition, what kind of a challenge, they are facing you with.

And then I would like to describe the strategy which we are evolving for that in simplified terms in three different areas: in our procurement programs, in our systems development programs, and our programs to build the technology base.

The competition with which we are confronted, I would describe as intense and continuous. There have been some writeups in the newspapers which describe this as some great new thing which has happened. Not so. The Soviet Union is pursuing this in a very systematic but a very determined way.

They have been investing about 12 percent of their gross national product on defense as long as we have been keeping records. That contrasts with about five percent of the United States gross national product invested in defense. So that gives you for openers a pretty good measure of the importance to which they place in their defense programs.

Now, as a consequence of this, as the Soviet economy has grown in the last few decades, so has their defense budget. And it has grown about three to five percent per year through the 1960s and the 1970s.

During that same time period, if you exclude the defense expenditures that were unique to Sotheast Asia, generally the U. S. defense budget has either been holding constant or has been declining in real dollars. The consequence, then, of this steady growth on the part of the Soviet Union, and the decline on the part of the U. S., is that we have gone from a position of expending about 40 or 50 percent more than the Soviet Union, something over a decade ago, to where they are now spending about 40 or 50 percent more than are we.

Throughout this period we have maintained, however, a technological superiority, and we still today base our defense strategy on the belief that we can use technology as a trump card, so to speak. While that is our strategy, I have to share with you some worries I have about that strategy.

The first worry is a fairly fundamental point, and it occurs to any of you who have studied, even casually, something known as Lanchester's Equations, which form a simplified model describing the relation between quantity and quality in warfare. Without discussing Lanchester's Equations, let me simply say in summary form: quality can't do everything. You have to have some quantity out there too.

In particular, the effectiveness of quantity varies as a square, and the effectiveness of quality varies as a linear proportion.

A second concern that I have with this strategy of technological lead, is that while we maintain a technological lead in the laboratories, it is taking us longer to get equipment into the field. Now, if it takes five years longer to get equipment in the field, we can evaporate a five year technological lead in the laboratory just by our procurement approach. Not only can we do that, we are in fact doing that.

Finally, and perhaps most fundamentally, I have a very significant worry as to whether we are going to be able to maintain a qualitative lead, and that is the major message that I want to leave with you today, and the major burden that I want to lay on you today.

Now let me take, then, these three items one at a time: our procurement strategy, system development strategy, strategy for technology base.

Relative to procurement, we have reasonably good evidence that the Soviet expenditures in this area are about twice what they are in the United States. The evidence for this I don't plan to discuss in any detail today. We observe that there are something more than 3,000 tanks a year being built in the Soviet Union, which gives us some handle on how much money they are spending in procurement. They have something on the order of 2,000 tactical aircraft being built. And in their ICBM program, we see something in excess of a thousand new re-entry vehicles being built and deployed each year.

Now, whether these items are good or bad in themselves is another question. But they provide compelling evidence that the Soviets are investing massively in the procurement of modern weapon systems, and support easily the conclusion that their investments in this area are more than twice those of the United States.

We have decided that we are not going to compete on a tank-for-tank basis, and that we are going to lean on technology as an equalizer here. This poses, in the procurement area, the very real problem that I described to you, then, of improving our procurement strategy so that we can get our technology out of our laboratories and into the field in a much shorter time.

You are involved in a very fundamental way in that problem, in the problem of achieving the transfer of technology from research into exploratory development. And I notice with some satisfaction that is one of the items that you will be talking about in workshops later on today. Let me encourage you to look very hard at that problem, because that is at the heart of our ability to compete effectively with the Soviet Union.

A second part of our strategy here is to use our Allies as equalizers. I talked about the increase in expenditures of the Soviet Union over the United States. If, on the other hand, we were to add the NATO defense expenditures to the United States, we would find that those are approximately equal to those of the Soviet Union plus the other Pact countries. So as an alliance we compete in defense expenditures, at least on paper. Unfortunately, the competition is limited to being on paper, because when you add up all of these systems, all of the equipment which we have, as an alliance, building and fielding, it still falls far short of what is being done in the Soviet Union.

The principal problem is the very inefficient nature of the way our defense dollars are spent as an alliance. With each of the countries developing and building their own weapons systems, not only poses very real problems, practical and logistical problems, in our operability, but more to the point for my discussion now, it simply reduces the efficiency of our defense expenditures, because no one country is able to achieve an efficient production run.

That is a problem to which we will be giving very significant attention, but which I don't plan to talk more about here today. I did want to underscore it as a basis on which it will involve you in the area of technology transfer considerations.

A second area of competition is the area of system development. And again, the best estimate we have is that the Soviet Union is expending about twice what we are expending in the area of system development. And we look for the evidence of that, and it is not hard to find. We see, for example, five ICBMs under development at one time today, four tactical aircraft under development, two main battle tanks. Now, this is in my view not necessarily a good approach for the Soviets to take in the development of their weapon systems. It is however a very clear indication of the level of resources that they are willing and, in fact, are putting into, the development of weapons systems. Our solutions here hinge primarily on our belief that we can be selective. That is, we don't have to develop five ICBMs in order to develop the right one. We can, by prior planning and prior study, determine what the optimum system is for us and develop just that system. That is in fact what we are planning to do in this field.

There also is, again, the potential of using our allies as an equalizer. Our R&D budget last year was $12.5 billion. The collective R&D budget of our allies was about $4 billion. So if we looked at that as a single pool of money, we would be looking at almost a $17 billion R&D program to work from.

Here though, even more than in the procurement area, the redundancy and the duplication simply defies the simple arithmetic of adding those two numbers together. The fact is that nearly all of our allies' R&D programs are in some way duplicative or redundant of what we are doing. Of course, from their point of view, they could put it another way around: that our programs are duplicative or redundant of what they are doing. So from whichever point of view you approach this, it is clear that you cannot simply add those dollars together and talk about a total correlated R&D base.

Our proposed solution to this problem, and which we have been discussing for some time now with our allies, is a program of sharing the development of weapons systems. This involves, on the one hand, the United States being willing to refrain from developing systems which we had

proposed and which we had planned to develop, and being willing to share our technology into the bargain. And secondly, it requires the allies agree, and here is a given ally with, say, a $1 billion R&D program, to agree to specialize, and to agree to specialize in some cases in very narrow fields.

We are working very hard to get agreement with the allies on this sort of an approach. It poses, I think you can appreciate, an R&D problem of the first order, to first of all get that agreement, and then secondly to carry it out. I and the Assistant Service Secretaries that are here with me today, will be involved in trying to get those agreements and drawing up the plan. You will be involved in the equally difficult problem of carrying it out if we have success with it.

Now I would like to get to the main point of my discussion this morning, which has to do with the technology base. We don't have, really, a good dollar estimate, or a good ruble estimate, for what the Soviets invest in their technology base. Our intelligence just is not particularly good in that area. We do have, however, a very authoritative statement of their intention in this area, and I would like to give you this one quote to underline my point.

This quote is from Chairman Brezhnev. He says: "The center of gravity in the competition between the two systems is now to be found precisely in the field of science and technology, making the further intensive development of the latest scientific and technical achievements not only the central economic, but also a critical political task, and giving to questions of scientific and technical progress a decisive significance."

This is the statement of policy under which the Soviets are working. What evidence we see suggests that they are following that very vigorously. I have had some opportunity to look fairly closely at the programs that they are engaged in in two different areas: the high energy lasers and the surface effect ships. And in both of those programs we have seen, for a good period of time, a long period of time, a 6.1, 6.2 type research program, and in both of those areas we see them transitioning now into the 6.3 and the 6.4 area.

It is very difficult to try to get some estimate of size on what we see, but I would estimate that in each of those areas, both the high energy laser and the surface effect ships, they are probably investing about a half a billion dollars a year. That is, they are probably engaged in an effort which, if we were to do the equivalent thing in the United States, would cost us about a half a billion dollars a year.

Now any of you who have looked at the United States R&D budget for those two areas recognizes it as quite minor compared with that. Whether they are on the right track in those two areas is another matter, and I am not at all sure that they are. But it is indicative of the seriousness with which they are taking this technical competition.

We have been saying right along that our trump card to these major expenses is our technological superiority. They have been observing the same thing, but they have not been accepting that, and they are working very hard to correct that problem.

There are solutions which we can try to remedy what is evidently a very serious spending imbalance in the field of defense, science and technology. Whether it is a two to one or a three to one discrepancy I can't tell you. It is very clear, though, that they are spending quite a bit more.

We have had a lead. We continue to have a lead. We have a significant industrial infra-structure, for which there is no comparison in the Soviet Union, but they are posing a challenge. They are not accepting that they will be second in technology.

Now, all of the different things we might apply here, and are trying, to apply in the way of management techniques are important, and I want to talk about them. But first and foremost is that in this area we simply must increase our expenditures.

We have started on a program -- the expenditures in our technology base today, and I am sure you have seen these figures before, are about half of what they were a decade ago, measured in real dollars. That is, our 6.1, 6.2 technology base is about half what it was then.

We started that program out two years ago; we have had some success in battling that more or less unscathed through two budget years. We are girding up our loins for the next budget year. I have argued as eloquently and as forcefully as I know how for that principle in our defense budget, and I will continue to argue that point.

We have, fortunately, substanial support from both the Secretary of Defense and the President on that point, and I think we are beginning to get stronger support from the Congress on that point. With that argument, there will still be the concern about managing better the resources we have. Even if we get this ten percent and five percent increase each year, we are starting from a base which is much smaller than the Soviet Union.

So the requirement for better management will still be there. That will involve better selection of programs, work effectively with allied technical community, and even within more effectively with each other, which gets us to the point if this conference.

I am very impressed with some of the subjects that I have seen for your meetings here today and tomorrow. How to support the S&T infra-structure, how to keep it fresh and imaginative, one of the items I saw which caught my fancy; how to improve our technology transfer from research to exploratory development; how to strengthen the use of academia and industry in the fields of S&T. And to that I might add: how to get more use

out of our allied countries in the fields of S&T. And how to pursue a strategic investment strategy in S&T.

All of those issues I commend to your attention today and tommorrow in your meetings. I would like to summarize now by noting that we are being challenged, and the challenge is not just a quantitative challenge, it is a qualitative challenge. It is a challenge to our technological superiority, it is a challenge to you, and directly to you.

DR. PERCY A. PIERCE

The last three of us are the workers, David Mann, Jack Martin, and myself. For my part, I intend to be fairly brief and fairly mundane. I would like to give you some impressions that I have formed over the last year or so in my association with Army labs, their functions, and their contributions; and to tell you a little about our view of those labs. By "our view" I mean my office view.

I would like to start by drawing to your attention the title that I carry, which is Assistant Secretary of the Army for Research, Development and Acquisition. I would like to give you a little background on that title and what we have done to try to make it work.

When I originally took this job, the job was Assistant Secretary of the Army for Research and Development. I sort of knew what that was all about. Later they added the acquisition function, and Dr. Perry has eloquently explained the advantages of having the acquisition function, that is, the quantity part of the equation as part of the R&D effort.

So the acquisition function was added, but in negotiating the organization that the Army would have in R&D the chief concern in taking over the new function was that we not dilute the attention given to R&D in the Army. Historically, the Army seemed to be the service that got the least money in R&D and perhaps gave it least attention. So that was a priority concern.

We addressed that concern the following way: I established a deputy for R&D: That is, my deputy, Dr. Joseph Yang, is not a deputy for RDA, but a deputy for R&D. So that he could have the time and opportunity to review programs in the laboratories in the tech base area, and give it the kind of attention that it had in the past, even though my attention might be needed to address some procurement problems.

We did another thing that I think is significant with respect to the attitude of the Army towards R&D and the work in the labs. That is, we reorganized the Army Scientific Advisory Panel Service Board. First of all we renamed it the Army Service Board, as I am sure many of you know, and secondly, we brought it into my office, rather than having it at a lower level. Dr. Lasser will be here later today to discuss Army lab directorship.

We still work closely with him, but he agreed with us that if the Army is to be serious about R&D and this kind of activity, then the Army Science Board ought to be brought directly under my attention. So those two things have been done: the establishment of a principal deputy and the Army Science Board.

We recently had a collaborative activity between the labs and Army Science Board. Some of you were probably in attendance at the Army Science Conference, held at West Point a few months ago. Members of the Army Science Board reviewed and selected the papers that received the awards. In short, there is a new organization in the Army, but I would just like you to know that we have taken every effort we could think of to ensure that R&D, that is, the tech base area, in the Army was given the visibility and attention that it deserved. I think it is working out. Those of you who are from Army labs please feel free to let me know in what ways it is not.

I talked to the Navy and the Air Force quite extensively before we made these reorganizations, and I am sure they have found solutions slightly different from ours. But they have the same problem, I am sure they are similarly concerned.

Our view of the Army labs, and when I say "our", again, I am talking about my current office, with respect to its function, includes three areas that I will discuss.

First of all, is the primary way in which we maintain the technology base, upon which the Army must build its programs. In that respect I would like to report that the Army, in the last two years, in the budget cycles that Dr. Perry mentioned, the has supported the goals of increased tech base. Traditionally, ASA(R&D) in the Army has been the man who at budget time had to fall on the floor kicking and screaming in order to protect the tech base.

That is the way it was my first year. I would like to report that this year we have generated a very strong ally for the tech base in General Rogers, the Chief of Staff of the Army. I am quite pleased by that. I take no credit for it. But today it is not only the ASA(R&D) who is concerned about the tech base, but the green suit Army has fenced the tech base. That is quite an achievement.

We also look to the laboratories as originators of new technology for improved weapons, and armament capabilities. As an example of that, just the other day there was an award, an incentive award, to some of our scientists at the Benet Laboratory at Watervliet. (The Benet Laboratory is a laboratory concerned with guns and parts of guns: tubes, breeches, and all kinds of things that are of interest to Congressman Stratton). These scientists got the maximum award, the maximum amount of money, which is roughly $30,000, $25,000, for a contribution which has saved us $30 million in one year, and will continue to save roughly $30 million, for us and the Navy, in the years to come.

This contribution had to do with fatigue testing of gun tubes. Instead of shooting real ammunition, which can cost $300 or $400 a

round, they found a way of simulating fatigue testing using hydraulics in a way that was acceptable to the Army. They not only found the way of doing it, the technical way, they had the persistance to push it and convince the Army and the Navy to accept it.

This is the kind of result that we would like to see coming out of our laboratories every month. But if we get that kind of contribution every few years, the laboratories will have strongly justified their existence as originators of new technology.

We also, thirdly, look to the laboratories to support one area where we need a lot of support. The Army is developing quite a few systems that are laser-guided. The Army is also out in front in night-vision devices, but particularly laser guidance. These are first generation systems, such as the Copperhead, which is a cannon-launched missile; the Hellfire missile, which can be on our attack helicopter. We will be depending upon laser guidance.

The big issue for the future that we need to be thinking about now is the issue of countermeasures to laser guidance. We are making a little progress in that area, but one of the big problems we face is how do you test a system under the kind of obscurance conditions with which we have to be concerned? And these involve weather, such as haze, fog. They involve aerosols of various kinds including smokes. So, given the progress we have made in trying to harden our systems against countermeasures, we need to be able to test them.

Down at Huntsville, Alabama, we have a project in the laboratory to develop a simulator, because it will be just about impossible to live fire enough rounds, enough missiles, in all kinds of environments in which we need to test them. In fact, it would be just about impossible to generate all of those environments and control the situations to do that kind of testing. So we are looking very strongly to the laboratory in Huntsville to give us simulators, that will give us sufficient confidence that we are beginning to handle that kind of problem.

Laboratories, as Dr. Perry, said, are in the business of being ahead in technology. That is, being ahead of the state of the art. The challenge is to move that technology into weapons systems. I would like to give you a few impressions of some Army labs, and I will caveat those impressions by saying that this is based on non-scientific review, my own visits to a variety of places. I would just like to tell you what has impressed me a little bit, with respect to technology lead.

I find that in our ballistics laboratories we are doing fine work. I mentioned the Watervliet fatigue testing simulation. But we have made

tremendous progress in other areas of ballistics at BRL and other labs. We are out in front, I think, in those areas.

One caveat that I would have to mention is that ballistics is an area in which, in this country, there isn't a lot of competition from private industry and the other services. Our night-vision lab is another laboratory where I think we are well out in front, however in this area there is a lot of competition, i.e., strong industrial people. But the night-vision lab is still very strong.

There is no question about the technological contributions there. So, those two impressions of technological lead, along with the other jobs that I have just mentioned our labs have to do, are the things for which we are looking to the labs. There are some concerns about the health and quality of our laboratories. And they revolve around manpower. My office, again, has a special and peculiar responsibility in this area, in that all of the Public Law 313 jobs come to my office for review, and that is a review that we take very, very seriously.

There are a limited number of these jobs, but they are very important. Beyond those super-grade jobs, the concern is that we maintain in the laboratories the quality and variety of people that we need.

I am told by DARCOM that personnel reductions, because of manpower problems, that have caused manpower strength in our labs to decline steadily since 1974, and the average age to increase. At some of the labs I visited that is true. We have a particular problem with respect to engineers. Having come out of a school of engineering I know the kinds of salaries that are being offered to first year engineers, and the kinds of salaries that we can offer. And we are, for starting salaries, something like $3,000 less on the B.S. level.

Also in the Army, as we expand our R and D, our project R and D and systems R and D, we make tremendous demands on the laboratories to support those projects, as opposed to pursuing, perhaps, more advantageous lines of inquiry. This is another demand that takes away manpower from the ongoing R and D that needs to be done. I don't have solutions for you for these problems, either the number of men, manpower, the salary levels, or the utilization of scientists, but I would just suggest to you that this is a continuing concern, and I hope that these lab directors here, both Army and otherwise, will pay some attention to them and continue to work on them.

In conclusion, I would just like to thank Ruth for giving me this opportunity to address some of my lab directors, and to share with the other lab directors some of the concerns and some of the things we have done in the Army. I would hope that, in the spirit of the joint meeting we are having right now between the Army Science Board and the Air Force Science Board, that the interaction among lab directors will be fruitful, and I wish you good luck. Thank you very much.

DR. DAVID E. MANN

I would like to be able to say that it is nice to come home again, but in the interest of precision I should, perhaps, point out that when I heard the National Bureau of Standards was moving to Gaithersburg I left. And so my experience with the Bureau of Standards ceased with the old Bureau on Connecticut Avenue. I guess the buildings are still there and it is known by another name.

I really appreciate the opportunity to say a few words to the ensemble of laboratory directors and other people who are concerned with the work of the laboratories, not so much because you are all here, but perhaps, in some sense, because we are all here.

Dr. Perry's remarks, which all of us in one form or another have echoed, made his pleas with eloquence and forcefulness. Some of us have gone so far as to engage in a kind of speechmaking which resembles evangelism more than it does the more usual forms of persuasion; occasionally even with some useful results.

And so I don't think that all of you, the 60 or 70 of you who are here, and particularly the many of you who represent the Navy system, need to hear again how important you are. I think all of you know this. You have heard us say it. I am sure you believe it, and in time we may even be able to persuade other branches of our government to that effect.

What I would like to do, however, is address, from my perspective, some of the perceptions that I have of the role, the varying roles, that the laboratories are called upon to play. In this respect I rather imagine that the Navy system, or the Navy centers or laboratories, are not all that different from those in the other services.

The Navy is very proud of its laboratory system, and its longstanding, in fact, rather glorious history, in conducting and supporting research. All of the people in the Navy are aware, but perhaps some of the other services aren't, that ONR, for example, which was founded immediately after the war, in 1946, has continued to be a viable organization, and that the level of 6.1 funding, in the case of the Navy, exceeds the funding level for either the Army or the Air Force by quite a margin. In our case it happens to be close to 180 million dollars a year, which even in this day and age isn't anything to be sneezed at.

If we add in 6.2 as part of the ensemble of technology base, this brings the total up to just about half a billion dollars a year. And I daresay that depending on how one counts or what one selects, that if we threw in 6.3A, at least on the Navy side, we would end up not far short of a billion dollars a year. I think one might say with some justice that that is a pretty fair technology base.

The centerpieces of much of what the Navy does in this regard are its laboratories and centers. The corporate laboratory, NRL, and the other more specialized laboratories, such as the one in New London, the one in San Diego, the one at Warminster, and so on, all differ in some degree, but their similarities are far more important as are their common problems. And rather than dwell on examples of a substantive kind, of what this lab did, or what that lab did, let me assume that all of you are familiar with it, and you can make the necessary correlation with the other services interalia.

What I would like to do, however, is describe some of the roles that the laboratories are being put into, some that they would like to have, some that they accept, and some that may, perhaps, not in the long term be in their best interests. With a view toward the workshops that will be conducted subsequently, and furthermore recognizing the profile that is to be given by the Director of Navy Laboratories, Dr. James Probus, later on, I will confine my attention to a brief mention of the roles and the identification of a few concerns. Let me leave it at that. They are concerns; they may or may not be problems. Much depends on the constraints, the policies, the management that pertains to the laboratories, at least in the Navy.

The in-house laboratories and centers serve a number of functions. I have grouped these into three categories, three classes; some functions that, in our view, we regard as vital and indispensable; some that we regard as necessary and useful; and some that we regard, or at least I regard, as optional and which may not always be desirable.

The vital functions all center on the laboratory's being an organized, very highly competent source of independent impartial judgment and of technical expertise that is quickly, readily, easily available to both the system development community and the decision-makers. They are the Government's people; we can count on them to be not only at hand, but to be objective, unbiased, impartial in the information that we obtain from them. And in this capacity, which I regard as the cornerstone or the keystone, if you like, of the laboratory's importance to the DoD, the laboratories can be called upon to provide expert, very broadly knowledgeable analyses, advice, appraisals, and what-not. This is an important point which sometimes gets overlooked in the rush to concern oneself about staff, and money, and management techniques, and the like. The fact of the matter is that the laboratories, to the extent that they preserve this important feature, are not in direct competition with industry, and they have the opportunity, an unusual one in this competitive day and age, of being able to look over all of the fences, of not being limited to considering and selling or advancing a particular approach or a particular interest or a particular gadget. This is, of course, not limited only to the Department of Defense laboratories; any of the nonprofit laboratories may lay claim to the same advantage, but

it is an absolutely invaluable one, considering the number of choices that the Department is called upon to make and the difficulty it has in obtaining what it can justifiably count on being unbiased, objective, and expert information.

A great value in this regard also stems from another factor, which in my view justifies and indeed nails down the importance of the laboratory to the Department, and that stems from their inherent stability and their very long term familiarity with defense peculiar or service unique problems, procedures, facilities, equipment, and the like. They are, and I hope they will continue to be, the Department's corporate memory. And as you, perhaps as a digression, look at your speakers today, or at least, those of us who have come from the Department, all of us or many of us, are very likely to be gone tomorrow, and much of the corporate memory that we may claim to have will disappear with us. Then, there will be a new set, and a new set, and the same of course is true to an accelerated degree in the case of the services, the uniformed service. So that, from a technical standpoint, the laboratories represent an absolutely invaluable repository, a memory, of technical development and familiarity for the military, a point that I think not only needs to be made; it needs to be stressed.

The laboratory that is readily available and easily taskable can also be called upon to undertake work which may be too sensitive, too unpredictable, too short-lived, or too urgent for accomplishment at acceptable risks and unacceptable costs within the private sector. The laboratories, at least in the case of the Navy labs, and I suspect the same is true for the other services, are intimately familiar with and consequently, very closely involved in direct fleet support activities, another point that we regard as absolutely vital. And finally, let me say that the laboratories are counted upon for technical innovation. The laboratories' involvement in research and related developmental activities is important to the Department. You can understand this, either as Department of the Navy and I am sure the Department of Defense, in two different ways, one, as a source of new ideas and technology, and secondly, as a matrix in which a technical staff can develop both the skills and the familiarity upon which we will subsequently draw in attempting to address our needs and our problems.

Among the functions which I would class as necessary and useful, as distinct from absolutely indispensable and vital, I would put technical direction in a kind of oversight role. In its technical direction role, the laboratory can provide the Department with a detailed and completely objective oversight capabilities to see programs through the travail of their developmental phases. This is something that need not, necessarily be done by the laboratory, but it can be and frequently it is highly desirable that a laboratory serve this function.

The laboratories also are involved in modes which I have described, for want of a better term, as optional or discretionary. Principally, these roles, in my view, involve two facets or aspects: one, their involvement in major system development activities, wherein the laboratory is placed in the position of becoming a major performer itself and of carrying the program through a full-scale or prototype phase. The laboratories are also frequently called upon to serve as extensions of the headquarters project management apparatus.

It is in connection with these two roles, or activities, or functions, that from my perspective, I see some problems, and I would urge that at least some attention be paid to these in some of the workshop discussions that will ensue.

The assumption of project management functions by a laboratory serves to divert technical staff into what I consider, with apologies to Dr. Perry and his staff, relatively unproductive management channels. Moreover, the attributes of objectivity, and independence, and ready access, or accessibility on a peer basis, on a technical working basis, may be regarded by a good many of the people with whom the laboratory is then called upon to deal with justifiable skepticism.

A similar concern can easily be imagined when the laboratory begins to engage in full-scale, fully run-out system development, in which case it falls into, if not conflict, at least a form of competition with industry, occasionally, large industry, which can't do the laboratory a great deal of good in the long pull and leads to some of the residual skepticism or uncertainty or doubt that may still be vested in the Congress, if not elsewhere.

These last comments have only touched the surface of some very real problems affecting the in-house laboratories and the laboratories, as everyone here representing the labs recognizes, are caught between not just a rock and a hard place but in the center of a high pressure field. They are faced with fiscal constraints on one side, they are faced with personnel ceilings on another, and they are faced with an ever increasing pressure for renewed, different, expanded activity, which tends to dilute, or to draw up, or draw down the very basis for their existence, much of their best technical staff, in order to provide services which, in a sense other parts of the Department, the Defense Department, are called upon or decide to requisition, because they themselves are in a bind. So, the laboratory finds itself compelled to respond to its masters, to its management, to its sponsors on the one side, and is unable to require or to retain the necessary flexibility internal to its own structure. The long-term difficulty that this poses to a laboratory I think is a very serious one, and I would point out that while I applaud, along with all of us here, the policy emphasis on renewed funding, increased funding, the recognition of the laboratory's central, vital role

in supporting the Department, that one cannot, must not lose sight of the constraints under which this funding can be applied. The laboratories may well find themselves confronted with the perhaps almost traumatic situation of literally having more money than they know how to use, simply because their uniformed service masters are drawing upon their resources on the one side, and then they are unable because of Congressional imposition of ceilings to expand their staffs. It is a thought that I suggest may be worth some further examination.

So, I would leave you finally with some questions, just a very few, but enough to illuminate or typify some of the concerns that I have.

How should the role of the laboratories' in-system development be defined or circumscribed?

How can block programming, a buzz word that has come to have a variety of implications and meanings over the last several years, be controlled or monitored to prevent abuses by the laboratories in control of the block funds?

That may be opening the closet a little bit and showing a little bit of dirty linen, but there isn't a one here among you who doesn't know exactly what I mean and what problems it may portend.

How can the laboratories deal with increasing pressure to engage in project management while under ceiling constraints?

Can or should the laboratories acquire the broad systems engineering expertise that in fact is needed for major system development tasks and which, parenthetically, most of the laboratories, at least the ones I am familiar with, do not really have. It is hard for them to get into competition with a Boeing or a Lockheed or a McDonnell-Douglas on that scale and in that way. And yet, occasionally, perhaps even unwittingly, they are called upon to perform functions as would require that kind of expertise.

And finally, how flexible should out-of-house contracting regulations be in respect to engineering as well as the support services?

Now, what I have tried to do is to suggest some perspectives and some questions, and I appreciate your time and your patience.

Thank you.

DR. JOHN J. MARTIN

Good morning, ladies and gentlemen. I'm delighted to be with such a distinguished group -- but I must add that it's a little intimidating to stand before so much of our technological talent and leadership. There might have been a time recently when I might engage in a scientific riposte, but I eschew that these days -- or try to.

Today, our scientific and technological capabilties are, in a sense, on trial. There is the scrutiny to which our efforts as scientists and engineers are subjected as a result of Soviet gains in military strength. This scrutiny prompts the question, are we doing enough to maintain our lead? There is the close review of that which the budget process entails. Such a review asks whether we are spending our science and technology monies prudently and to good purpose.

In a very important way, you are a part of the jury in this trial: your daily decisions will determine the final outcome. But addressing this "jury" is a difficult task for me. To those of you affiliated with the Air Force, I can take the role of a judge delivering his charge to the jury. But to those of you affiliated with other organizations, I must speak as an attorney pleading his case.

Nevertheless, in both instances the message is the same: we must seek to optimize, to maximize the strength of our resources and talents through cooperation which must however, avoid monolithic thinking in technical matters. Such cooperation can and must take many forms. At its most fundamental level, cooperation must exist between the labs associated with each service. To take advantage of the "teaming" effect and to minimize unconstructive duplication of effort, we also need cooperation among all the labs within the Defense Department, whatever the color of the uniforms happens to be. Furthermore, we need to get universities and industry involved in doing the things that they can do best in support of Defense. And then in a sort of coup de grace, we need to transfer this cooperative spirit to the international arena to the extent that our national interests permit and encourage. NATO immediately comes to mind as a focal point for this approach.

In NATO, the quest for the interoperability and standardization that leads to increased readiness demands that we arrive eventually at mutually acceptable single answers, single products, and single approaches. This is best done where national investments have not yet been made, where parochial interests still do not exist. In other words, this can be done best by beginning at a technology level, leading in due time to development and acquisition. Fruitful areas with immediate possibilities for optimizing our common posture in NATO might inlcude new munitions, fuels, and data links.

Some of the structure for such cooperation already exists, for example, in AGARD (the NATO Advisory Group for Aerospace R and D) and in the SHAPE Technical Center. But we need to approach with great seriousness our interaction with our allies in these forums. We need to approach these meetings with knowledgeable and open minds, and then we need to expend the necessary effort to ensure that results ensue.

For our part, we realize that there are some institutional and procedural barriers to full interaction with our NATO allies at the reasearch and development level. We in the Pentagon are working on overcoming these barriers, and expect to do so successfully.

Let me turn briefly to another aspect of cooperation: the need for cooperative interface between research and development, on the one hand, and logistics, on the other.

Organizationally and philosophically, there has been a real but unintended separation between R and D and logistics. The first has been seen as being largely logical and analytical, the other somehow largely intuitive, synthetic, holistic. But I would submit that the labs need to apply analytical methods to support problems that normally seem to resist solution through analytical means. In the Air Force, as some of you know, we have recently asked our Scientific Advisory Board to try its hand at solving some of the subtle but nagging problems that we face in maintaining and operating our aircraft. They will be looking at ways to improve reliability, maintainability, and economy. These are vital areas especially in this period of tight budgets and diminished manpower levels.

Likewise, I see the labs increasingly involved in a wide range of activities that can be grouped under the rubric of "logistics support." These activities will help us solve near-term but highly complex problems, such as controlling or reducing the effects of corrosion on aircraft in the field; or developing an environmentally safe paint stripper; or devising new methods of rapid but durable repair for damaged aircraft. At the other end of the spectrum, the labs will continue to explore entirely new weapon systems concepts, thereby keeping us in the technological forefront.

A couple of years ago, I would probably have argued that work at the long-term end of this spectrum was the more important. But in the last year or so, my perspective has broadened. With the association in the Air Force Secretariat of R and D, Acquisition and Logistics, in response to an SEC DEF initiative, I have become much more aware of the problems involved in keeping our aircraft flying and of the vital need for interface between the design phase and the support phase of a weapon system's life.

In the Air Force, we are encouraging such interface through more direct, more organic relationships between our Systems Command and Logistics Command. And our goal is to ensure that support and maintenance are given full consideration throughout the design phase.

After all, readiness depends not only on our ability to put the latest technology on the front lines of defense. It also depends on our ability to put this technology in the air on short notice, wherever and whenever necessary. If it can't fly because it needs time-consuming repairs or maintenance, it does not add to our readiness, in either real terms or as perceived by potential adversaries.

Now, ladies and gentlemen of the jury, the rest is in your hands. It is up to you to exploit and apply our vast scientific and technological capabilities in the interests of national defense. After all, and I quote, "It is by devising new weapons, and above all by scientific leadership, that we shall best cope with the enemy's superior strength." That was what Winston Churchill said to his War Cabinet in 1940, during one of Britain's darkest hours. That philosophy is as valid today as it was then.

Thank you.

SECOND SESSION

Conference Objectives S&T in DoD Trends and Planning	DR. RUTH M. DAVIS Deputy Under Secretary of Defense for Research and Advanced Technology
The DoD S&T Program Today	COL. DONALD I. CARTER Military Assistant to the Deputy Under Secretary for Research and Advanced Technology ODUSDRE(R&AT)
Technology Initiatives: Environmental & Life Sciences	CAPT. FRANK H. AUSTIN, JR. Director, Environmental and Life Sciences ODUSDRE(R&AT)
Technology Initiatives: Engineering Technology	MR. GRESHOM R. MAKEPEACE Director, Engineering Technology ODUSDRE(R&AT)
Technology Initiatives: Electronics & Physical Sciences	MR. LEONARD R. WEISBERG Director, Electronics and Physical Sciences ODUSDRE(R&AT)
Research Initiatives	DR. GEORGE GAMOTA Assistant for Research to the Deputy Under Secretary of Defense for Research and Advanced Technology
High Energy Laser Initiatives	COL. ROBERT T. POPPE Military Assistant for Directed Energy Programs ODUSDRE(R&AT)
Manufacturing Technology	DR. LLOYD L. LEHN Assistant for Manufacturing Technology to the Deputy Under Secretary of Defense for Research and Advanced Technology

DR. RUTH M. DAVIS

The purpose of this meeting is to concentrate almost entirely on the substantive formulation of our DoD science and technology program. For example, it is not intended that we discuss personnel and administrative problems, "lines of command" problems, or individual laboratory programs except as examples for points to be made. These and a number of other issues mentioned by our previous speakers are extremely important. However, we are specifically not addressing our attention to these items at this conference. This is one of those instances where already it is apparent that we need a second conference.

We are trying in the DoD science and technology program to meet the kind of objectives that Bill Perry has stated to the Congress. We want to emphasize the role of the DoD science and technology program as a part of the process in the Department of Defense that starts with basic research and ends up as a fielded system. The emphasis placed on the science and technology program is well placed because this activity is less expensive than in systems, such as in terms of manpower, time in developmental prototype testing, developmental cycle costs and so on. As Bill Perry has correctly stated, you can't do much with the DSARC process if you don't have the ideas and technological options available as input.

I want to emphasize the role of the DoD science and technology program as an integral part of the RDT&E and procurement process of the Department. You have already heard Bill Perry mention that technological superiority is one of our stated goals. Technological superiority prevents technological surprise from happening to us and allows us to use technological surprise as a weapon. One's technological superiority is determined on the basis of the kind and length of leads you have and is technology specific, and one cannot talk about a single lead for the entire DoD science and technology program.

I refer to the terminology "science and technology program" rather than the "tech base" because I believe it helps one appreciate the process of science and technology. One gets a better feeling for the differentiation between the roles of academia, industry, in-house laboratories, and the kind of management and funding required for them. The science and technology process is comprised of the three facets: "invention," which refers to creativity or discovery; "innovation," or the first successful application of an invention process; and "diffusion," or the spread of a successful innovation. These terms are also excellent separators in terms of function, types of management, and kinds of resources and capability that we need.

Although we will be talking about the entire science and technology process, you will see throughout my charts (appended) emphasis on the

word, "technology." In previous charts I gave you the terms invention, innovation, and diffusion. Science is really synonomous with invention. The phraseology of technology that we are comfortable with includes not only the front end of what we field in equipment, but also the know-how, information, and procedures to keep these fielded items maintainable while they are in operation.

There is a differential type of role for industry and academia in the science and technology process, in a way based on the unique responsibilities of a customer, such as the Department of Defense. Generally, one nowadays finds that industry is concentrating on the "me too" systems. This is a "safe course" where there is a large probability of success in innovation, only slightly less than unity. When industry is not sure of what the customer wants that is new, they will put major efforts where there is the next highest probability of success, namely a new product in an old market. Occasionally when industry feels a bit more comfortable with the customers, they will look at an old product in a new market. But generally to come up with a new product in a new market, for which the probability for success in innovation is least, requires a very knowledgeable and intelligent customer. Generally in the fields of high technology, that customer has been the Department of Defense. It has been a very unique role that the DoD and laboratories have played in taking responsibility for deciding what those products are for new DoD mission needs, and then translating that for industry in a typical marketplace role.

I find that one of the best ways of marketing the DoD science and technology program is to indicate that we know what makes for technological events. You get changes through breakthroughs, through incremental improvements, and through a combination of the two. It is extremely important for both, to do as much as we can of assessment and prediction which are imprecise sciences in themselves. Most important, it is necessary to have a technological infrastructure to carry forward as we search for breakthroughs and make the incremental advances. There are always certain technological areas which appear to be the pillars or columns or mortar between the bricks for building up to operational objectives or to other technological objectives.

As an example of the infrastructure that we advanced for the 1979 budget cycle, I have given you some exemplary areas:

<u>DEFENSE TECHNOLOGY INFRASTRUCTURE</u>
<u>(1975 - 1985)</u>

Microelectronics Technology
Computer/Software Technology
Sensor ("Observables") Technology
Materials Technology
Human Engineering Technology
Automation Technology (Unmanned Systems)
Distributed Systems Technology
Manufacturing Technology

These seem to be the driving areas, the areas that are pervasive throughout all of the needed markets that we have between all three services. These are also the driving areas for ensuring that we have enough resources, and the confidence to push in the areas of technology that you see there that are essential to the known systems that we want.

So we have described, marketed, and sold our FY 1979 and FY 1980 DoD science and technology program on the basis of a very strong technological infrastructure. This is the framework for what we need and what we are fielding. It also demonstrates an understanding of how to look for technological breakthroughs by knowing enough about science and technology to hunt them and find them by knowing where they may occur. We have also marketed the program by concentrating very strongly on the incremental improvements in science and technology that are necessary to drive the system forward through the infrastructure, and as we await the technological breakthroughs.

At this point, I would like to turn the program over, having given you just a slight overview of how we look at the DoD science and technology program, to Don Carter who is the Military Assistant in my office, and Don will address the subject of the DoD science and technology program today.

WHAT THIS MEETING IS NOT INTENDED TO DO

A. Not discuss laboratories funding issues separately from the substantive content of the DoD S&T program.

B. Not discuss personnel/administrative problems.

C. Not discuss individual laboratory programs except as examples for points to be made.

D. Not discuss "lines of command" problems.

DEPUTY UNDER SECRETARY (R&AT)'S INTENTIONS

A. To emphasize the importance of the proper substantive (technical) content of the DoD S&T program.

B. To involve directly the DoD technical laboratory directors in the formulation of the substantive content.

C. To assess the DoD S&T program in terms of:

   1. Its past contribution.

   2. Its present vigor.

   3. Its future structure.

D. To increase the interaction between the DoD S&T community and the university research community.

E. To develop on the part of DoD and Congressional management an understanding of the complementary roles of industry and DoD laboratories in DoD's S&T program.

F. Publish summary of conference achievements.

G. Distribute and discuss conference findings with OSD management and with OSTP.

TECHNOLOGY STIMULATION, MANAGEMENT AND EXPLOITATION

Present objective in DoD: Disciplined selectivity of a few weapons system options; availability of desired large option menu here is dependent upon enlightened diversity in developing S&T.

High priority placed on strongly competitive environment in technology

Otherwise system selection is a captive rather than a beneficiary of available technology options.

Reviews in 26 areas of technology provide reasonable comfort that desired competition in technology will occur.

System design, management, acquisition policies and funding are not substitutes for scientific and technological inputs.

Competition in technology is comparatively "inexpensive" vis-a-vis system competition.

Competition in S&T should generally be proportional to:

1. Potential operational payoff.
2. Scientific uncertainties.
3. Quantity planned for procurement.

TECHNOLOGY SUPERIORITY IS STATED GOAL

TECHNOLOGICAL SUPERIORITY

- Prevents technological surprise from happening to us
- Allows us to use technological surprise as a weapon

TECHNOLOGICAL SUPERIORITY

- Is generally measured in terms of technological lead time
- Is technology-specific

THE SCIENCE AND TECHNOLOGY PROCESS

INVENTION:	Creativity or discovery
INNOVATION:	The first successful application of an invention process
DIFFUSION:	The spread of successful innovation

TECHNOLOGY

TECHNOLOGY CONSISTS OF THE "KNOW-HOW", THE PROCEDURES, THE INFORMATION, THE DATA, THE EQUIPMENT AND THE SERVICES SUPPORT TO:

- Design and manufacture equipment, and
- Successfully operate and use fielded systems (incl. maintenance)

PROBABILITY LAWS FOR SUCCESS IN INNOVATION

	CHANCES
1. A new product in a new market: the ultimate in innovation	1 in 20
Ex: The first satellite for any use, e.g for RECCE	
The first blender for any use, e.g. in home	
2. An old product in a new market	1 in 4
Ex: Reconnaissance satellite for agriculture market	
The home blender in the hospital market	
3. A new product in an old market	1 in 2
Ex: RECCE satellite using IR (not photo)	
Home blender five times faster than any other in market	
4. An old product in an old market or the "me-too" product	Slightly less than 1 in 1

TECHNOLOGICAL CHANGE

The means for technological advance occurs via:

1. Scientific/technical breakthroughs
2. Incremental improvements in existing products/systems
3. A combination of #1 and #2

Technology assessment - an unproven technique

Technology prediction:

1. Too optimistic in near term
   - Incremental improvements prove difficult
2. Too pessimistic in long term
   - Can not predict breakthroughs

TECHNOLOGICAL INFRASTRUCTURE
FOR MILITARY APPLICATIONS

Infrastructure - underlying foundation or basic framework of the defense science and technology program

Its characterization is key to:

- Technology advance
- Setting priorities
- Investment strategy

Its components provide the support for the entire range of military technologies and applications.

DEFENSE TECHNOLOGY INFRASTRUCTURE

(1975 - 1985)

- Microelectronics Technology
- Computer/software Technology
- Sensor ("Observables") Technology
- Materials Technology
- Human Engineering Technology
- Automation Technology (Unmanned Systems)
- Distributed Systems Technology
- Manufacturing Technology

TECHNOLOGY ADVANCES

Examples of Incremental Improvements

1. Aircraft engine thrust-to-weight ratio

    45:1 to 8.5:1 in 20 years

2. Microwave power tube bandwidth and efficiency

    Doubling in 15 years

3. Aluminum alloy strength to density increases 30% in 10 years

TECHNOLOGY ADVANCES

EXAMPLES OF TECHNICAL BREAKTHROUGHS (Occurring or anticipated)

1. "Computer" Technology

   One hundredfold increase in speed and capacity accompanied by one hundredfold decrease in cost in 10 years (1960-1970's)

   - Magnetic cores
   - Semiconductors (Microelectronics)
   - Networking
   - Digital Communications

   Million bit chip by late 1980's

2. Night Vision Technology

   Tenfold increase in sensitivity and tenfold decrease in cost in 10 years (1965-1975)

   - Image intensifiers
   - Photo Cathodes (GaAs)
   - Coolers
   - IR Detectors

3. Controlled Thermonuclear Reaction (CTR) Technology

   Millimeter wave heated Tokamacs Stellarratars or Laser Heated Pellets

   Energy Revolution (to come)

4. Directed Energy Technology

   Anticipation of pulsed power switches (10ths to 100ths of a millisecond switch time)

   Conditioned beam propagation

5. Composite Materials Technology

   Graphite/aluminum yields

   A. More than 500% power gain increase over aluminum

   B. More than 50% power gain increase over graphite epoxy

COL. DON CARTER

Our Science and Technology Program (or 6.1, 6.2, 6.3A and Manufacturing Technology Programs) just exceeds $2.7 billion in our request for FY 1979. That is about an 11 percent increase over our budget for FY 1978. It is also broken out by Service and Defense agencies, with the Defense agencies being the DARPA Program and the Defense Nuclear Agency.

Another way that we can look at our program is by how much money we put into particular specialities, if you wish. The Research Program is about $420 million per year; our Mobility Program is about $475. we look at mobility as air vehicles, land vehicles, sea vehicles -- how you get to where you are going. The Weapons Programs are what you do when you get there -- bombs and bullets, guns, high energy lasers, things of that nature. Our Electronics Program is quite large, as probably it should be, and our People Program is increasing at a fairly high rate lately.

I would also like to call your attention to the Manufacturing Technology Program.

So far as who we are in the Research and Advanced Technology business, I believe that most of you are familiar with the three, if you wish, "old-line" aspects of our office, the Environmental and Life Sciences Program, the Engineering Technology Program, and the Electronics Program. A couple of changes over the past six or eight months have taken place. For example, we have established the research program as a special office reporting directly to Dr. Davis. You will hear more about this office from Dr. George Gamota.

In addition, the High Energy Laser Program, primarily in the 6.3 business, has been transferred to our office. The Manufacturing Technology Program, which originally was in the old Installations and Logistics Shop, has also been transferred to our program. You will be hearing separately from each of those offices a little bit later this morning. I would also like to point out that we have a specialist for Information Management (Mr. Andy Aines) as we are putting quite a bit of more emphasis on what we do with our product.

Also we are in the Technology Export business, that is, how we assure control of those technologies that are militarily critical and, at the same time, don't interfere with international commerce, and that is Col. John Hagar who is also here.

At this time I would like to introduce our Director of Environmental and Life Sciences, Capt. Frank Austin.

CAPTAIN FRANK AUSTIN

I am pleased to be here on this as first of the "old-line" because we have an identity crisis with Medical and Life Sciences very often. An M. D. in your program, Dr. Moore, is listed as Aerospace Medical Division; he could have been called the Anti-Missile Division if they followed the pattern for Billy Welch for SAM, Surface-to-Air Missiles. Welch is from the School of Aviation Medicine. I once named one of my departments, LSD, Life Systems Division, and you can understand the problem I got into there!

(Vu-graph #1)

This is the scope of the area which I cover, Medical Training and Personnel, Chemical and Biological Environmental Quality as opposed to Environmental Sciences -- Environmental Sciences, Oceanography, Aerology, et cetera.

We have considered ourselves dealing with the people, with their psychology, their physiology, their health, protecting them, but we don't do much in the realm of classic medical or surgical research, as you probably know already. That is done in other areas. Then, of course, our other large area is the environmental, from the core of the earth to space.

ENVIRONMENTAL & LIFE SCIENCES

- Medical and Life Sciences
- Training and Personnel Technology
- Chemical and Biological Technology
- Environmental Quality
- Environmental Sciences

Vu-graph 1

(Vu-graph 2)

This gives you a feeling, as Don had already given you, of a breakdown of our figures for 1979 and 1980 for the various areas, $500 million roughly. We do have in our office a good deal of 6.4 programs that we monitor just because we have the expertise, but that is not shown here.

(Vu-graph 3)

In breaking down into categories of technological infrastructure, incremental improvements and potential breakthroughs, these are our major thrusts. There is about -- considering the fact that it is a very broad based area, there is about only one thrust per customer shown here. Prophylaxis and therapy for chemical casualties is certainly one of our major ones and it is coming up as being a big requirement. Infectious disease technology certainly is giving us a lot of troubles; we still have trouble getting our forces into areas and keeping them healthy. The others are, I think, easy to understand and are self-explanatory.

(Vu-graph 4)

This vu-graph illustrates the areas we cover in chemical defense.

We are looking for new systems, new alarm systems, because our old systems

don't provide the necessary capabilities. An example is an ionization detector that is being procured by the Services now; it is an advanced model to detect chemical agents.

Other areas of major thrust in our Environmental and Life Sciences area, actually, this advanced technology demonstration slide covers medical and life sciences. The human factors and environmental will come in a moment as a separate area. I might point out tht anti-malarial drugs in our medical area are very important; the malaria bug keeps getting immune to the new drugs we develop. We are really trying to get improvement by vaccination in this area.

We are working very hard in the area of simulators, automated, innovated, adaptive training and maintenance training.

One of the demonstrations listed, of course, is an oil/water separator which helps keep our ships from polluting the environment.

We are going to advanced simulators, wide angle vision systems and computer generated vision systems for our computers. These are major thrusts, now.

We have gotten laser engagement systems for simulation during maneuvers.

ENVIRONMENTAL & LIFE SCIENCES

	FUNDING FY 1979	FY ($M)* FY 1980
Med & Life Sci	142	148
Training & Personnel	103	121
Chem/Biological	48	61
Env Protection	32	31
Env Sciences	139	152
Total	464	518

* Includes 6.1 thru 6.3 Army, Navy and Air Force

Vu-graph 2

II

EXPLORATORY DEVELOPMENT (6.2)

- Technological Infrastructure
  - Prophylaxis and therapy for chemical casualties
  - Military infectious diseases technology
  - Hazard protection and performance effectiveness
  - Visual and perceptual characteristic of displays
- Incremental Improvements
  - Detection and warning systems for C/B attack
  - Simulation and training technology
  - Selection and classification
- Potential Breakthrough
  - Vaccine and malaria prevention
  - Accelerated drug prophylaxis testing against tropical diseases
  - Non-corrosive decontamination fluids for chemicals/biologicals
  - New fabrics for protective overgarments
  - Computer adaptive testing
  - Artificial intelligence for generative CAI

Vu-graph 3

We are pushing our simulation technology into the fields of -- beyond aviation -- into tank crew simulators with full crew interaction simulators.

(V-egraph 6)

Now in Environmental Sciences, we go from the core of the earth to the farthest star, covering the terrestrial, oceanic, atmospheric and astronomical sciences.

(Vu-graph 7)

And with the same breakdown of technological infrastructure, et cetera, you will see some important thrusts in this area.

(Vu-graph 8)

Certainly it is necessary for any sensing system to sense through the atmosphere and to do it against natural and manmade (perhaps enemy produced) background, and that is why atmospheric transmission is one of our major thrusts. We are trying to get the ocean forecasting and the associated systems refined for ASW and other applications, and we hope for some breakthroughs in the areas listed.

I

ENVIRONMENTAL SCIENCES

- o Ocean Sciences
- o Atmospheric Sciences
- o Terrestrial Sciences
- o Astronomy

Vu-graph 6

II

EXPLORATORY DEVELOPMENT (6.2)

- Technological Infrastructure
  - Atmospheric Optics
  - Ocean Variability
  - Ionospheric Structure
- Incremental Improvements
  - Numerical Weather Prediction
  - Satellite Data Interpretation
  - Ocean Forecasting
- Potential Breakthroughs
  - Remote Ocean Profiling
  - Remote Atmospheric Sensing
  - Non-Acoustic ASW

Vu-graph 7

III

ADVANCED TECHNOLOGY DEMONSTRATION

- o Global Weather Prediction Model
  - -- extend useful forecasts to 7 days
- o Satellite Data Assimilation
  - -- make optimum use of the dense dust of digits
- o Naval Environmental Display System
  - -- Rapid distribution of environmental data to the fleet
- o Environmental/weapons Effects Prediction System
  - -- provides optimum decision in assistance to weather system operator
- o Precision Time/Time Interval Program
  - -- Worldwide timing standards for all DoD users

Vu-graph 8

MR. GERALD MAKEPEACE

My plan today is to give you a quick overview, a very quick one, of the Engineering Technology Organization, or E. T. as most of us call it, and then some flash looks at a few of the highlight areas among the technologies we monitored.

(Vu-graphs 1 and 2)

These are our areas of concern, as they break down into the technical area description or TAD categories, which many of you are familiar with. For each of them, I have cited the funding expected in the Fiscal 1979 President's budget and the name of the E. T. specialist who does the monitoring. Most of them are here, or will be, for this session.

Now, the bottom line of the funding, over here, is what we hope to get for this coming year. What we will get, of course, is still under debate in Congress. You will note that the 6.3A budget is quite large. Those of you who have looked at the workshops that are planned for this afternoon and tomorrow will recognize that one of them will focus upon the meaning, merits, and demerits of 6.3A as a part of the Defense Department S and T program.

Well, let's now move on to our flash looks at some of the thrusts in this program for Fiscal 1979.

(Vu-graph 3)

Let's look first at the advanced fighter technology integration test vehicle, AFTI. Probably the most striking feature of AFTI is the ability to aim the entire aircraft, and thereby its ordnance, in directions different from those associated with the flight path of the aircraft.

This can give us a much increased flight envelope, as compared with the conventional fighter, for target attack. Only a fully integrated digital flight and fire control system makes the whole thing practical and useful, however.

ENGINEERING TECHNOLOGY

		FY1979 $M
Aeronautical Vehicles Technology	Osborne	112.3
Aircraft Propulsion Technology	Standahar	111.1
Ocean Vehicle Technology	Osborne/Standahar	112.4
Land Mobility Technology	Standahar	47.2
Tactical Missiles G&C Technology	Kopcsak	112.1
Missiles and Space Vehicles Propulsion	Makepeace	58.9

Vu-graph 1

ENGINEERING TECHNOLOGY (CONT.)

		FY1979 $M
Torpedoes and Undersea Mines Tech.	Kopcsak	21.2
Guns Technology	Thorkildsen	73.2
Landmines and Countermeasures	Thorkildsen	17.6
Bombs and Ordnance Tech.	Thorkildsen	13.5
Materials and Structures Tech.	Persh	128.6

* * * * * * * *

Total 6.2 - $515.9M ---------- 6.3 - $235.9M

Vu-graph 2

<u>ADVANCED FIGHTER TECHNOLOGY DEMONSTRATIONS</u>

"AIMABLE" AIRCRAFT

HIGH-G SEAT AND CONTROLS

INTEGRATED DIGITAL FLIGHT AND FIRE CONTROL SYSTEMS

Increased Maneuverability Vehicle

More Target Acquisition Paths

Large Extension of Pilot Capabilities

Improved Tracking Accuracy

More Target Kill Opportunities

Higher Aircraft Survivability

Wider Range of Combat Uses for Aircraft

Vu-graph 3

(Vu-graph 4)

Aircraft turbine technology development has made enormous progress from a very shaky start at the end of World War II. It is still making good progress through a continuing series of evolutionary improvements in the critical components. New inlets, compressors, combustors, turbines, and thrusters, combined in test-proven engines have made the U. S. the world leader in aircraft propulsion.

Concentrated attention is now also being given to adaptation of advanced electronic technology in the form of fully integrated and much simplified engine control systems, to new materials technology, including ceramics, for very high temperature combustion as in turbines, and to engine designs able to make use of the wider range of liquid hydrocarbon fuels.

(Vu-graph 5)

Helicopters are comparative newcomers to an important role in direct combat support. Few would argue, however, with their importance in Viet Nam. Still they do have serious limitations in speed, range, stability, and maintenance requirements. Technology work now in progress could drastically change helicopter performance and remove some of these limitations. The tilt rotor, circulation controlled rotor and the x-wing, which is a stopped rotor concept all have potential in various combinations for flight speeds approaching the trans-sonic, for much increased range, and for enormous simplification of the lift/thrust mechanisms.

One notes the simplicity of the circulation controlled rotor hub as compared to the mechanical rat's nest of the conventional hub. Everything is done with airflow control rather than rotor tilt and blade pitch control. It may even be feasible in the future to eliminate the tail rotor.

Helicopters, some day, could become effective air combat and assault vehicles.

Well, we have talked quite a bit about advanced vehicles, though not as much as I had intended to, and the new conventional weapons concepts are equally promising. Perhaps the most exciting area of all is the new terminal guidance system technology.

ADVANCED AIRCRAFT PROPULSION SYSTEMS TECHNOLOGY DEMONSTRATIONS

Hotter, more efficient turbines - better combustor temperature distribution

Compressors with more pressure rise per stage

Fully integrated electronic control systems

System responsive inlets, fans, power turbines, and exhaust nozzles

Wider acceptable range of fuel properties

Higher thrust per lb. and per cu. ft.

More responsive yet simpler engine controls

Better engine efficiency over a wider range of operating conditions

Satisfactory performance and life with wide specification fuels

---

More mission-capable aircraft

Simplified logistics -- lower maintenance requirements

Vu-graph 4

NEW HELICOPTER TECHNOLOGY

Advanced airfoils - reduced drag configurations

Simplified rotor drives and controls

Novel systems concepts

Tilt rotor - circulation controlled rotor - X-wing

Improved speed, payload and range

Lower procurement cost - better energy performance

Higher reliability - longer MTBF

New military options for helicopter use

Greater vehicle capability in conventional uses

More helicopters continuously available in combat duty

Vu-graph 5

(Vu-graph 6)

I am particularly enthusiastic about multi-mode, multi-spectrum devices with upcoming capability to function equally well, day or night in all kinds of weather, and with a complete fire and forget capacity. They haven't quite arrived yet at a price we can afford to pay, but I am confident that they will.

Already, the prospects for extraordinary kill capabilities of enemy tank formations at long distances look entirely real through use of free rocket carriers of sub missiles with individual terminal guidance.

(Vu-graphs 7)

Important technological improvements are being made to both rockets and ram jets. Some of the most exciting ones are in air-breathing missile propulsion. Liquid fueled ram jets are ready for systems application and solid fuel ducted rockets will not be far behind. After them will come solid fuel ram jets.

Subsonic expendable turbojets are already here in cruise missiles, and supersonic versions may be practical in a few years.

For all of these air-breathing propulsion devices the attractive features, in broad terms, are the same. The target kill envelopes around the launch point are much larger than for conventional tactical rockets, and the full propulsive power is maintained to target and permits more effective terminal homing on moving targets.

(Vu-graph 8)

For many years, gun technology was relatively quiescent. It is active again now since we have discovered missiles won't do everything and guns are necessary after all. Work is in progress on new gun propellants, long life barrels, projectiles without cartridge cases, and advanced fire control systems. Work has just begun on a concept for a dramatically improved 155 millimeter self-propelled howitzer. At first glance, the howitzer may look like just another gun on a tracked transporter. Far from it! This gun has automated weapon placement, aiming, loading and ramming, and soft recoil. The doubled projectile range and sustained firing rate speak for themselves. The high fast rate of fire is novel for a weapon of this size, and the whole system can be operated with several fewer people than required by today's 155 Millimeter Howitzer.

TERMINAL GUIDANCE SYSTEM TECHNOLOGY

Active---------Semi-Active---------Passive---------Multi-Mode

Command---------Inertial---------Correlation Guidance

Laser---------Electro-Optical---------Infrared---------MM Wave---------Multi-Spectrum

---

Cloud and Rain Penetration---------Night Capability---------Ground Clutter Discrimination

Fire-and-Forget

High probability target destruction - at - *greater* standoff ranges

Useful in all kinds of weather, day or night

Reduced collateral damage

Favorable economic exchange ratios - and - reduced logistics burden

Vu-graph 6

AIR-BREATHING MISSILE PROPULSION

Ducted Rockets ---------------------------- Ram Jets

Solid Fuel -------------------------------- Liquid Fuel

Fixed Flow -------------------------------- Controllable Flow

Expendable Turbojets

Thrust time capabilities increased several-fold

High supersonic speeds sustainable throughout flight

Maneuvering power available near target

Weapons effective at longer standoff ranges

Much increased area of kill around launcher

Higher kill probability on moving targets

More evasive maneuvering capability

Vu-graph 7

ADVANCED 155MM SELF-PROPELLED HOWITZER

Automated vehicle positioning and weapon orientation

Automated loader and rammer systems

High performance gun and ammunition

Soft recoil - minimal gun displacement

Doubled firing range - doubled sustained firing rate

High burst rate of fire

High mobility - short time to initiate firing

Large area of weapon effectiveness

Quick response to firing demand

Low personnel requirement - excellent logistics

Vu-graph 8

(Vu-graph 9)

Now, everything is made from materials and we are interested in all of them. I will conclude this very quick review by noting just two relatively new ones. They seem to have some important properties and applications, so we are pushing technology work on them.

Metal matrix composites are made from aluminum or other metals reinforced with graphite or ceramic fibers. The analog, of course, is fiberglass reinforced epoxy but the properties are in another regime altogether.

(Mr. Makepeace concluded with a picture of a carbon-carbon nose tip for a ballistic missile and data concerning erosion during re-entry.)

SOME DoD SYSTEMS APPLICATIONS FOR

METAL MATRIX COMPOSITES

Supersonic Aircraft Structures	Armor
Laser Shielding	VSTOL (Heat Ducts and Shields)
High K.E. Penetrators	Air Frames
Laser Benches	Helicopter Gear Cases
Satellite Structures	Hot Missile Structures
Electrical Machinery	(Tactical and Ballistic)
Marine Gas Turbines	Turbine Buckets, Desk, Rotors
Fan Blades	Combustion Chambers
Honeycomb Skin	Bearing and Seals
Bomb Fins	Current Collection
Hydrofoil (Foils and	Brushes
Struts)	Aircraft Brakes

Vu-graph 9

MR. LEN WEISBERG

In this first chart, I have broken out the areas of electronics technology according to their major function, and, for those of you who are not familiar with electronics, we can consider the first five of these as the eyes, ears, voice, nerve system and brains of our military systems.

(Vu-graph 1)

The next to the bottom function of electronic warfare includes those functions that serve to disrupt these above five functions or to try and protect our systems from being disrupted.

The final function, electronic devices, is the basic program that feeds the above six programs with their building blocks. It is out of this program that some of the major advances have emerged in electronics, such as either directly as the laser, or indirectly as with integrated circuits.

(Vu-graph 2)

In the case of the overall funding, if we include roughly $100 million in research the total comes to close to $500 million for electronics technology.

The largest problem is surveillance, and the reason this is so large is that it covers a very broad area, encompassing radar, undersea acoustic surveillance and battlefield surveillance, which has night vision as a major entity.

The area that has been growing the most rapidly is electronic warfare. This increase is purposeful to meet the growing threat. This whole electronic warfare technology program will grow by approximately a factor of two from FY 1977 through FY 1980.

Under "Unconventional and Supportive Electronics" is our work on charged particle beams and automated test equipment.

ELECTRONICS TECHNOLOGY

Surveillance	Eyes
Target Acquisition/Fire Control	Ears
Communications	Voice
Command and Control	Nerve System
Information Processing (Computers)	and Brains

Electronic warfare

Electronic Devices

Vu-graph 1

ELECTRONICS TECHNOLOGY - FUNDING

($ - MILLIONS)

	FY 1978
Surveillance	93
Target Acquisition/Fire Control	40
Communications	17
Command and Control	42
Information Processing	23
Electronic Warfare	53
Electronic Devices	63
Unconventional and Supportive Electronics	51
Research	100
TOTAL	482

Vu-graph 2

(Vu-graph 3)

Here we consider development, and we have broken the program out according to the three major categories, the infrastructure type programs, those providing incremental improvements, and programs that will do much more, we hope, than incremental improvements. In the first, I include electron devices as one of the major infrastructure programs. It should be realized that even though this is stated as a single program, it is really broken up into many parts which, by themselves, are infrastructure programs such as microwave tubes, lasers, infrared detectors and integrated circuits.

Another infrastructure effort is signal processing. Many of our electronic systems handle signals. We have to be concerned with pulling the signal out of the noise, out of clutter and interference. We have to learn how to make our signals difficult to detect, in terms of signal distribution. We have to not only know how to distribute signals appropriately through broad areas such as with internetted systems but, indeed, onboard a single platform vessel such as an aircraft.

Concerning incremental improvements, in microwave tubes, we have seen very big changes in efficiencies. Efficiencies doubled over 15 years through many minor improvements. Again, in microwave solid state, over a decade, we have seen powers increased by over an order of magnitude.

Now, going down to potential breakthroughs, in terms of charged particle beam technology, many of you are familiar with this program, and compared to high energy lasers, it also gives us a way of delivering energy directly on to a target virtually instantaneously. However, we still have to move something like another two to three orders of magnitude ahead in power to have a viable weapon system, and this tells you right there that this program is very much still in the early stages of development. We have a long way to go here and, in fact, we have been analyzing this problem, analyzing, for example, what exists today in this entire field, whether it is under the Department of Energy, or whatever applications one can think of for particle beams.

Next, we considered what are the improvements we need to make this a viable system. By taking these two templets and inter-comparing them, some of the major deficiencies have become quite evident -- these are for example -- how do we store these large amounts of powers for short lengths of time and how do we switch this amount of power very rapidly?

Turning to very large scale integrated circuits, any of you who have bought a calculator lately for four or five dollars knows what has happened in this field. We have jumped in the last decade essentially two entire generations of technology where we replaced over 50 integrated circuits with a single integrated circuit today. This is one of the major areas where we have gotten not only performance advances but also decrease in price simultaneously, a very rare event.

We are now starting a new program again to jump our technology roughly comparable to where we were on the top of that slide to the bottom, again two orders of magnitude ahead, we can either take our present systems where we might have 30, or 40, or 50 integrated circuits or more and shrink them down to perhaps one or two, or put the equivalent of a large IBM computer, the brains of a large IBM computer, for example, in a missile guidance system.

Turning to blue green lasers, these can penetrate remarkably far, over a hundred feet through the water. We have been working in this area because of the advantages it can give us in terms of communicating with a submarine, or detecting or tracking submarines. However, we still have a ways to go. We need a factor of 10 more power, and after we get that, we still need to increase the efficiency by an order of magnitude so that our systems don't draw too much power. Again we have programs progressing rapidly.

ELECTRONICS TECHNOLOGY - EXPLORATORY DEVELOPMENT

TECHNOLOGICAL INFRASTRUCTURE	o Electronic Devices (e.g., ICs, Microwave Tubes, Lasers)
	o Signal Processing
	o Signal Distribution
INCREMENTAL IMPROVEMENTS	o Microwave Tubes
	o Microwave Solid State
	o Signal Networks
	o Radar Countermeasure Protection
	o Software Life Cycle Costs
POTENTIAL BREAKTHROUGHS	o Charged Particle Beam Technology
	o Very Large Scale Integrated Circuits (VLSI)
	o Blue-Green Laser
	o Infrared Detector Arrays
	o Acoustic Signal Processing
	o Noncooperative Identification

Vu-graph 3

(Vu-graph 4)

These are our advanced technology demonstrations, Programs 6.3A. The first is mini remotely piloted vehicles, which in the case of the Army will allow us to see over a hill, that is extend our ability to see. These will take the place of a forward observer to tell us where the enemy forces are, direct artillery fire to them, and in fact even give us a laser designator function.

These small "birds" are only about a 10 foot wing dimension, weighing about 150 pounds or so. The RPV is caught in an upper net, and then afterwards it falls down to a lower net. This landing system has been very effective, and in fact this program will be moving to engineering development in FY 79.

Of course you know that night vision is extremely important in terms of the way we conduct combat at night, and in fact our FLIR program has progressed rapidly. It is serving as a basis of some NATO initiatives, we have signed an MOU with the Federal Republic of Germany, and we are now discussing an MOU with France and the United Kingdom. The night vision goggles are very sophisticated goggles that work beautifully; very good for helicopter pilots and soldiers who drive trucks. But it is an expensive system. It costs on the order of $8,000 per pair of goggles. We are now working on reducing the costs of these goggles through using some advances made in the field of photoemitters and related advances to try and reduce this cost down to $2,500. The importance here is not just simply the reduction in cost, but how many of these you can give out to your troops in the field.

The last topic I will address is the Ring Laser Gyro. Our present conventional gyros use spinning parts, a rotor or a wheel to sense inerital motion. Here we use a laser beam. The laser beam goes around in this triangular path. As that system rotates, the frequency of the laser shifts. We can detect that frequency, and from there get the rate of motion. The advantage is that essentially we have no moving parts, the typical solid state advantage with the much higher reliability it affords. Because of that, the amount of repair and calibration is much reduced. We estimate over a 10 year cycle this would give us a savings of $150,000 per inertial system.

That in the nutshell is the Electronics Technology Program.

ELECTRONICS TECHNOLOGY - ADVANCED TECHNOLOGY DEMONSTRATIONS (ATDs)

- MINI-REMOTELY PILOTED VEHICLES (RPVs) - OVER-THE-HORIZON SURVEILLANCE OF TARGET DESIGNATION (OPENS DOOR TO UNMANNED COMBAT)
- NIGHT VISION - CHANGES NIGHT COMBAT; INCL. GOGGLES, FLIRs, Mm WAVES
- RING LASER GYRO (RLG) - SAVES $150K PER GYRO; USE IN TACTICAL MISSILES
- MAGNETIC ANOMALY DETECTOR (MAD) - USES JOSEPHSON JUNCTIONS; GREATLY INCREASE SUB DETECTION AND LOCALIZATION; PROVIDES TRACKING
- ALL WEATHER TACTICAL STRIKE SYSTEM (AWTSS) - CAPABILITY FOR PRECISION WEAPON DELIVERY IN ADVERSE WEATHER
- UV MISSILE WARNING RECEIVER - CAPABILITY TO WARN HELICOPTER OF MISSILE LAUNCH
- ELECTRO-OPTIC COUNTERMEASURE POD - ONLY CM AGAINST OPTICALLY DIRECTED WEAPONS
- DIGITAL AVIONICS (DAIS) - PROVIDE SIMPLER INFORMATION TO PILOT; ALLOWS SIMPLER AND LOW COST UPDATES
- CHARGE-COUPLED DEVICE TV CAMERA - COMPACT, RELIABLE, AND LOW POWER FOR MISSILES, RPVs, PERISCOPES, AIRCRAFT SURVEILLANCE
- FIBER OPTICS LINKS - SMALLER SIZE AND WEIGHT, NO RADIATION EMITTED, FEWER REPEATERS
- MODULAR AUTOMATIC TEST EQUIPMENT - PREVENT PROLIFERATION OF CUSTOM SYSTEMS PRESENTLY COSTING DOD $1.4 BILLION ANNUALLY

Vu-graph 4

DR. GAMOTA

Good afternoon. It is my pleasure to be here today and give you a brief overview of the Research Program. First, I think it is worthwhile to remember what the objectives of defense research are.

DEFENSE RESEARCH OBJECTIVES

- PROVIDE A BROAD BASE OF FUNDAMENTAL INFORMATION IN THE SCIENCES AND IN ENGINEERING

- DISCOVER NEW PHENOMENA OF POTENTIAL BENEFIT TO LONG-TERM DEFENSE NEEDS

While it might sound like motherhood, I think it is very important to keep in mind these objectives when we make a decision on letting out a contract or starting an in-house capability. Too often I found projects that have been started without these objectives in mind.

I think it is also very important to remember that we have a very broad based research program. In essence we span the gamut from astronomy to zoology. However, by no means is the program evenly divided in funding. We obviously have areas where we fund much more heavily than others. In order to give you a better perception of the funding situation on the next slide I have broken down the research areas into five broad technology areas.

FUNDING BY TECHNOLOGY AREAS (FY 77)

	Army	Navy	Air Force
Electronics	29%	22%	27%
Materials	31%	27%	32%
Aero	21%	6%	20%
Environmental	10%	36%	13%
Life Sciences Human Resources	9%	9%	8%
	100%	100%	100%
Total	($98M)	($155M)	($35M)

DEFENSE RESEARCH PROGRAM DESCRIPTION

DOD RESEARCH (6 1) PROGRAM PROVIDES THE BASE FOR EXPLORATORY AND ADVANCED DEVELOPMENTS IN DEFENSE RELATED TECHNOLOGIES. IT INCLUDES WORK IN THE FOLLOWING DESCIPLINES:

- PHYSICS
- ...EMISTRY
- MATHEMATICS
- ELECTRONICS
- MECHANICS
- MATERIALS
- OCEANOGRAPHY
- TERRESTRIAL SCIENCES
- ATMOSPHERIC SCIENCES
- ASTRONOMY & ASTRO-PHYSICS
- BIOLOGICAL & MEDICAL SCIENCES
- BEHAVIORAL & SOCIAL SCIENCES

First, electronics and materials take up more than half of the program in all three services. Furthermore in environmental services you will note that the Navy has the largest program, 36 percent. This is due to the fact that they support a large oceanography program.

Finally, in life sciences and human resources you notice that we have roughly about 10 percent, maybe a little bit less than 10 percent, of the funding. I think this is an area again that is very important, particularly as we get into an age where computers and very complex machinery and the average IQ sort of have to coalesce. We have to understand the machine and the man interface much better than we have up to now.

You might also note that the Navy has the smallest mechanical and aeronautical program. This is due to the fact that they have decided to put most of their program into the 6.2 category.

Here I have one funding chart to show you what has happened to defense research. The dotted line is the constant fiscal '78 dollars. As you know, starting in '68 until about '75 we have been skidding. We lost about 50 percent of the program.

In '75 a reversal started, and I am happy to say that through '79 and hopefully in through '80 it looks very good. We have turned the corner, and we are trying to regain the momentum. There is a long way to go before we are able to see our light back to where we were in '68. The program now for Fiscal '79 is $470 million. This includes DARPA. Forty percent of the work is done inhouse, 40 percent at universities, and the remaining 20 percent in industry and non-profit organizations. The intent of my next vu-graph is to show the infrastructure of 6.1. It is all infrastructure. If you try to relate, say, some projects in physics, you will find by the number of check marks where there is the largest correlation. However, you have to be very careful in this kind of a scenario because, for instance, in air vehicle technology you don't see any check marks in physics. That means that as far as I am concerned physics is not important to air vehicle technology.

The problem with that kind of an understanding is that physics is the basis for mechanics and materials, and mechanics and materials, of course, is very important to air vehicle technology. So what I have done with these check marks is show you the first order correlation.

I picked out one example of how infrastructure works in 6.1, and that is shown in this slide.

MATHEMATICS o		o HIGH ENERGY LASER CANDIDATE
PHYSICS o		o ELECTRONIC DEVICE
ELECTRONICS o	FREE-	o ELECTRONIC WARFARE
MECHANICS o	ELECTRON	o SEARCH
MATERIALS o	LASER	o GUIDED MISSILES & ROCKETS
CHEMISTRY o		o COMMUNICATIONS
		o MATERIALS RESEARCH FACILITY

As you know, the free electron laser was first demonstrated last year. The work was done at Stanford and supported by AFOSR. We are very excited about the prospect of having a broadly tuned high energy source of radiation. What was needed to put it together? Well, on the left you see math, physics, electronics, mechanics, materials, and chemistry. Every one of those items played an integral role in making that laser go.

To the right are listed possible applications. I don't know if it in fact will turn out that all of the areas will utilize the free electron laser, but I think we have the option now of looking at all of those possibilities and seeing if it is a viable option for future defense needs. It is obviously a candidate for a high energy laser, for an electronic device, for electronic warfare, for search, and for guided missiles and rockets. The ballistic missile people are very interested in it. In fact, they are starting a 6.2 program.

What I have done in the last couple of minutes is try to cite some categories or thrusts which I feel are important in defense research. There are two broad categories which I will label as incremental improvements, these are really technology options, and the other category is concerned with technology breakthroughs.

You might disagree with some of the items for instance, the near millimeter waves. I think it is a very exciting possibility of being able to augment IR and radar. There is a lot of work going on and I certainly support it. However, I think that it will incrementally improve our capability. It will not drastically change our way of thinking.

Another possibility here is cloud and aerosol physics, an important area that needs to be supported and hasn't been in the last year or two. I would like to cite a recent example but unfortunately it is classified. The naval weapons people have done it. It is a new system of a smoke that has very unique characteristics. Anybody who is interested may come back and talk to me privately. But it has completely unique characteristics, and if deployed hopefully will really cause a lot of problem to our enemy.

I don't want to spend a lot of time talking about some of the other things because I am sure you can appreciate that all of these things are very important and if solved will definitely improve our system capability.

INCREMENTAL IMPROVEMENTS

- BLUE-GREEN LASERS
- NEAR-MILLIMETER WAVES & DEVICES
- NON-LINEAR EVOLUTION EQUATIONS
- CLOUD & AEROSOL PHYSICS
- NON-DESTRUCTIVE EVALUATION PROCESSES
- COMPUTER ARCHITECTURE FOR NUMERICAL AERODYNAMICS
- UNDERSTANDING OF TURBULENT FLUID FLOWS
- IMPROVING SURVIVABILITY UNDER CHEMICAL, BIOLOGICAL, & RADIOLOGICAL ATTACK
- IMPROVE HUMAN PERFORMANCE CAPABILITIES UNDER VARIOUS MILITARY ENVIRONMENTS
- TRIBOLOGY

Below are shown areas for potential breakthroughs. There are my blue sky projects. I really feel that this is the heart of defense research sciences because without the blue sky projects we have no hope of discovering, say, another laser. I don't mean a laser, but I mean the concept of what laser did to technology. We would have no concept of coming up with a transistor. I think we need to support blue sky work where it is on the frontiers of science and is of potential use to DOD needs.

POTENTIAL BREAKTHROUGHS

- o NEUTRINO COMMUNICATION
- o SPIN ALIGNED HYDROGEN
- o X-RAY LASER
- o ULTRA SUB-MICRON ELECTRONICS ($\lesssim$ 1000 Å)
- o PROPAGATION OF CHARGED/NEUTRAL PARTICLE BEAMS
- o HIGH TEMPERATURE SUPERCONDUCTIVITY
- o ARTIFICIAL INTELLIGENCE
- o UNIVERSAL BLOOD DONOR
- o AURORAL IONOSPHERIC PHYSICS
- o RESEARCH OPENED UP BY THE SPACE SHUTTLE
- o ANTIVIRAL MEDICINES

An example of a potential breakthrough is the use of neutrios for communications. I refer to man-made neutrions, with a cross section large enough so that you could detect them, and provide a unique communication system.

Spin aligned hydrogen is a source of energy that is 50 times greater than from HMX and something that we ought to look at. I don't know where it is going to lead, but the science that goes into getting that project going is something that I am definitely sure that will pay off in the long run.

In auroral ionospheric physics, there is a concept that is rather new of being able to provide a communications system by harnessing the auroral streams. I think this is also something that we ought to look at.

Finally in the last slide, I show sort of a combination of the previous two, but here define funding initiatives. I want to make sure that those areas are covered adequately.

RESEARCH AREAS NEEDING STRONG SUPPORT

- o ULTRA SUB-MICRON ELECTRONICS
- o ENERGETIC MATERIALS
- o UNDERWATER ACTIVITIES
- o NON-DESTRUCTIVE EVALUATION PROCESSES
- o UNDERSTANDING OF MAN-MACHINE INTERFACE
- o SIGNAL PROCESSING
- o ARTIFICIAL INTELLIGENCE
- o NEAR EARTH SPACE ACTIVITIES

The first one is ultrasubmicron electronics. Here I think unlike the 6.2 effort that Len Weisberg talked about I want to see us go beyond the submicron work, toward the region of 10 to 1000 Angstroms. There is a lot of basic physics, chemistry, math, and everything else that has to be done. We have to understand those quantum systems. I think it is our job in the research community to be able to advance the technology so that in 10 years or when industry is ready to move into it, we will have the answers for them.

Another area that I would like to mention is near earth space activities. With the space shuttle coming aboard, I think it is a unique opportunity for us to do some experiments near earth and provide answers for some unanswered questions.

COLONEL ROBERT POPPE

The Department of Defense is spending about $180 million per year on high energy laser technology development in a program motivated by the reasons shown on vuegraph 1. In essence, we can envision a highly capable weapon system that is largely immune to limitations of missiles and guns, and that can complement missiles and guns in several mission applications.

Vu-graph 2 shows in priority order, the overall goals which guide this program. The program is in an early advanced development stage with the present emphasis beginning to shift toward those demonstrations that will provide the basis for key decisions in the early 1980's on the continuing thrust of the program.

Some examples of potential applications are shown in the artist concepts in the next vu-graphs.

First, there is defense of capital ships against missile and aircraft threats.

Next, we view defense of high value assets in the theatre of operations against aircraft and precision quided weapons.

Finally, there are several potential offensive and defensive applications of a laser on an aircraft platform.

REASONS FOR DOD INTEREST IN LASER WEAPONS

- UNIQUE WEAPON CHARACTERISTICS
  - INSTANTANEOUS DELIVERY OF ENERGY
  - POTENTIAL FOR GREAT FIREPOWER
    - MULTIPLE KILLS
    - RAPID RETARGETING
    - EXPANDED FIELD OF FIRE
  - CAN ENGAGE HIGH SPEED TARGETS
  - LESS SUSCEPTIBLE TO ECM
  - LOW COST PER SHOT
- MAY REVOLUTIONIZE SOME ASPECTS OF TACTICAL WARFARE
- MAY HAVE LONG TERM STRATEGIC IMPLICATIONS
- HELPS ASSESS POTENTIAL SOVIET THREAT

DOD HEL PROGRAM OVERALL GOALS

1. VERIFICATION AT THE EARLIEST PRACTICAL DATE THAT HEL WEAPONS CAN BE SUFFICIENTLY LETHAL TO BE COMPETITIVE WITH OTHER MEANS TO PERFORM THE MISSIONS OF INTEREST

2. CONTINUING EXPANSION OF THE TECHNOLOGY BASE TO SEEK NEW CONCEPTS IN LASER DEVICES AND OPTICAL SYSTEMS THAT COULD YIELD MARKED INCREASES IN THE CAPABILITIES OF HEL WEAPONS AND NEW APPLICATIONS

3. PROVIDING A SCALABLE TECHNOLOGY BASE TO SUPPORT, WITH CONFIDENCE, DECISIONS TO INITIATE DEVELOPMENT OF PROTOTYPE WEAPONS AT THE TIME COST EFFECTIVENESS IS DEMONSTRATED

HIGH ENERGY LASER PROGRAM

The HEL program is truly multidisciplinary. The key components of a hypothetical laser weapon system include both the laser itself where there are several approaches to generating the high-power light, and the beam control system, which directs the light to and focusses it on the target. Like all other weapons, the laser weapon system must have a fire control system which acquires the target selects the one to engage and aims the weapon at the target. In addition to the usual scientific and engineering activities, special attention is devoted to the understanding of how a laser beam propagates through the air and interacts with the target. Moreover, in light of the possibility that the Soviets may eventually develop a laser weapon system, we are devoting significant resources to an investigation of techniques by which we could harden our weapon systems to increase their survivability in a laser weapon environment.

Since the objective of the DoD program is to examine the feasibility of developing high laser weapon systems which are capable of effectively engaging and destroying selected targets. In consonance with this objective, the DoD is engaged in technology development programs which will culminate in a series of feasibility demonstrations.

The test bed for the Air Force program is the Airborne Laser Laboratory, a highly instrumented NKC-135 aircraft. The Air Force is investigating not only the integration and operation of high energy laser components in a dynamic airborne environment, but also the propagation of laser light from an airborne vehicle to an airborne target.

The Army has completed experiments using its Mobile Test Unit which consisted of a moderate power laser system mounted on a USMC LTVP-7 tracked vehicle. The Army is now examining the feasibility of laser-weapon concepts in uniquely typical air defense scenarios.

The Navy is completing its field-test program at the San Juan Capistrano Facility near Camp Pendleton, California and is developing plans for a test series in the 1980's at the DoD HEL test facility being developed in the White Sands Missile Range, New Mexico. The Navy program places particular emphasis on the integration of an advanced beam control system with chemical lasers.

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The current and past funding of the program is as shown below:

	Prior	FY 1977	FY 1978	FY 1979
Army	118.1	21.0	13.7	17.3
Navy	172.7	44.1	33.2	33.8
USAF	264.9	79.9	76.3	94.3
DARPA	187.6	23.8	25.3	38.0
TOTAL	743.0	168.8	148.5	183.4

DR. LLOYD L. LEHN

ASSISTANT FOR

MANUFACTURING TECHNOLOGY

I - OVERVIEW

MANUFACTURING TECHNOLOGY

- **PURPOSE**
  - TO PROVIDE FOR TIMELY, RELIABLE & ECONOMICAL PRODUCTION OF DEFENSE MATERIEL
- **OBJECTIVE**
  - TO DEVELOP NEW AND IMPROVED MFG TECHNIQUES, PROCESSES AND EQUIPMENT
- **SCOPE**
  - PROJECTS ADDRESS GENERIC MANUFACTURING TECHNOLOGY
  - SUPPORTS OVERALL DEFENSE PRODUCTION BASE
  - PROCUREMENT FUNDED EFFORT - PROGRAM ELEMENT 78011 INDUSTRIAL PREPAREDNESS NOT AN R&D PROGRAM - FEASIBILITY MUST HAVE BEEN DEMONSTRATED
  - RDT&E FUNDED EFFORT - PROGRAM ELEMENT 63728N DEMONSTRATES FEASIBILITY
- **BENEFITS**
  - REDUCES COSTS AND LEAD TIMES AND IMPROVES QUALITY AND RELIABILITY
  - AVOIDS DUPLICATION OF EFFORT
  - PROVIDES PROVEN MANUFACTURING OPTIONS TO DESIGNERS
  - CONSERVES CRITICAL MATERIALS, IMPROVES SAFETY, REDUCES POLLUTION
  - PROVIDES SPINOFFS TO PRIVATE SECTOR

II-REPRESENTATIVE MT EFFORTS

- DEPLETED URANIUM PENETRATORS
- INTEGRATED COMPUTER AIDED MANUFACTURING
- SHIPS BEAM BENDER
- AUTOMATIC PROPELLANT BAG SEWING
- HOT ISOSTATIC PRESSING FOR TURBINE BLADE REJUVINATION

III FINANCIAL DATA

($ MILLIONS)

	1977	1978	1979	1980	1981	1982	1983
ARMY	62.7	63.4	70.9	75.7	90.8	89.8	85.5
AIR FORCE	33.4	40.0	27.1	58.3	66.9	72.8	74.1
NAVY	14.8	10.8	20.8	33.6	42.1	45.4	62.0
TOTAL	110.9	114.2	118.8	167.6	199.8	208.0	209.4

As of 22 January 1978

IV MISSION NEED

MISSION NEED	REPRESENTATIVE ITEM IN MT PROGRAM
COMPUTER AIDED MANUFACTURING	- DESIGN OF SHEET METAL CELL - FLEXIBLE MFG SYSTEM FOR TRACKED COMBAT VEHICLE COMPONENTS
MUNITIONS BASE MODERNIZATION	- ULTRASONIC EXTRUSION OF PROPELLANT - DETONATOR TRAPS
NEAR NET SHAPES	- COLD AND WARM ROTARY FORGE TECHNOLOGY - LOW COST HIP CANS
REDUCE JOINING COSTS	- ADVANCED BONDING TECHNOLOGY - LARGE AREA REPAIR FOR BONDED STRUCTURES
REDUCE SURFACE TREATMENT COSTS	- LASER SURFACE HARDENING OF COMBAT VEHICLE PARTS
REDUCE METAL REMOVAL COSTS	- CUTTING TOOL COATINGS - HIGH SPEED MACHINING
REDUCE INSPECTION COSTS	- AUTOMATED BLADE CONTOUR INSPECTION

V-RECENT GUIDANCE

- $200 MILLION/YR PROGRAM BY FY 1983
- RDT&E LINE ITEM
- CONTINUE COST DRIVER ANALYSES
- MT OFFICE/PROJECT MANAGER INTERACTION
- REVIEW MT OFFICE RESOURCES
- STRENGTHEN INDUSTRY COORDINATION
- IMPROVE IMPLEMENTATION OF PROJECT RESULTS
- IMPROVE METHOD OF MONITORING PAYBACK

WORKSHOPS

WORKSHOP 1

Discussion Leader: Col. Donald Carter (R&AT)
Topic: Laboratory Participation in the Substantive Formation of the DoD S&T Program Strategy

WORKSHOP 2

Discussion Leader: Mr. Gerry Makepeace (R&AT)
Topic: The Proper Role of Advanced Technology Demonstration (6.3A) in the Research to the System Acquisition Cycle

WORKSHOP 3

Discussion Leader: Dr. George Millburn (Aerospace)
Topic: Forecasts for S&T Breakthroughs; Strategy for their Pursuit

WORKSHOP 4

Discussion Leader: Mr. Len Weisberg (R&AT)
Topic: The DoD S&T Infrastructure: What should it be and how should it be supported?

WORKSHOP 5

Discussion Leader: Dr. Peter Franken (Director of the Optical Sciences Center, University of Arizona)
Topic: The Military Research Forefront: What current areas comprise it and how can they be supported?

WORKSHOP 6

Discussion Leader: Dr. Bill Nierenberg (Director of the Scripps Institution of Oceanography, University of California, San Diego)
Topic: What S&T Strengths are Now Available to DoD from Academia and Industry?

Workshop #1	Colonel Don Carter, Discussion Leader Mr. Jerry Persh Col. John Hager
Topic	Laboratory Participation in the Substantive Formulation of the DoD S&T Program Strategy
Objective	To broaden and more clearly delineate the role of the Technical Director from decisions concerning internal laboratory programs to contributions to an overall S&T strategy.
Questions	(1) How do you presently prioritize S&T programs within your laboratory? (2) What formal/informal mechanisms are used in your prioritization process to reflect (a) needs of the user, (b) opportunities evolving within the S&T program, (c) work in other laboratories of your Service, (d) work in other Services and (e) OUSDRE Technical Area Descriptions. (3) How can communicaions between OUSDRE and the laboratory management be improved?

COL. DONALD I. CARTER

My workshop was charged with defining a broad and clearly delineated role for the technical director in contributions to the overall S & T strategy.

It was an interesting session. It lasted a little bit longer than the time that had been allocated.

The workshop evolved into four basic parts. One would be the Technical Director participation; secondly would be communication; and third would be decision authority; and fourth would be other needs thrown in at the end.

Insofar as the TD's feelings on how they participate currently in the overall formulation of the S & T strategy, they thought it was quite high.

They particularly felt that it was high, and I tend to agree with them, within their technical areas and within their Services. They, in essence, determine their needs (the needs for their technology) based on their discussions with the systems commands and with the operational folks, as well as taking a look at what is coming out of their technology program.

They are able to prioritize their needs, and consequently they felt that from their aspect, their contribution to the science and technology program, in an upward manner from the laboratory, is very high.

Some of the Navy representatives felt that they didn't have quite as much control over the entire 6.2 program at the TD level as they perhaps should, i.e., the problem of funneling the funds through the SYSCOMs to the Navy laboratories.

In general, the TDs felt that there was more participation needed by them, however, this seemed to me to be a little of a contradiction to the first point.

However, if one considers their contributions to the overall S & T program, then I can see their point. They felt that we needed a mechanism for an explicit decision making process with feedback in both directions, i.e., how the TDs make their decisions and feedback to us in OSD, and vice versa.

That leads into the next topic, which is communications. At first there was some of the old adage that a young second lieutenant learns when he first gets into the Service: that you don't ever want to ask higher headquarters for guidance, because, one, they will probably give you some, and secondly, you probably can't live with it.

But we passed that one, and I believe that the consensus was that more communication is needed between the TDs and the OSD. The TDs would particularly like for us to define for them, probably in a fashion that we haven't yet, what we would feel would be our thrusts for their particular areas, with particular emphasis on the intelligence portions of what we feel they should be doing.

There was a good bit of discussion regarding the intermediate headquarter's influence on the communications between OSD and the TDs. The TDs looked at their programs as being integrated packages of 6.1, 6.2 and 6.3 programs that they put together so that the 6.1 flows to the 6.2 to the 6.3 and so forth; they do have a logical package. When the TDs present their programs to intermediate headquarters, they invariably submit it not as an integrated package to an individual, but they present portions of their integrated package to different offices within the intermediate headquarters. The offices in the intermediate headquarters then perform their revisions and prioritization across the broken up packages, perhaps through two or three echelons, before it arrives at OSD. Then we look at it again as a package (6.1 plus 6.2 plus 6.3) which is not necessarily still integrated

There was a good bit of discussion that perhaps this technique could be improved. The TDs expressed a need for a continuing dialogue with us, and I believe that referring to the "more communications needed" and insofar as how we felt about your programs and how you felt about our evaluation of your programs.

There was some discussion regarding the documentation of the programs from two aspects. One was in the guidance documents that we prepare, such as the Consolidated Guidance and the Technical Area Descriptions. The TADs are not necessarily guidance documents, but they do give an indication to you of how we feel about your particular area. And indeed, I don't believe the documents are getting down to the TD level. We will have to increase our communications in that fashion.

The second problem voiced, however, was does OSD really need all of those documents that the laboratories are required to prepare? They noted such items as 1498s, 1634s, descriptive summaries, the topical and program reviews and so forth. So I believe that that is one that we should take a look at.

The next general area of communications that needs to be improved is between the TDs and DARPA, or between the science and technology program and DARPA. That is one that we should take under advisement insofar as where we go from here.

Now, insofar as the decision authority is concerned, the TDs generally felt that they were, indeed, influencing the technical decisions that needed to be made, i.e., the technical decisions of what type of materials

to investigate for application to jet engines, etc. They did feel that on occasion intermediate headquarters and the OSD became too involved in the decision process, say, the $200,000 decision level. I tend to agree with them on that.

The TDs did express some concern regarding OSD providing guidance which is too specific and thus could result in severe fluctuations of their supporting science and technology programs when major programs such as the B-1 are cancelled.

Insofar as the gratuitous items are concerned, the TDs suggested a retrospective study of a couple of program areas, or technical areas, if you wish, that are fairly highly successful. An example given was the rocket propulsion area: in which we seem to have an integrated, coordinated program across the three Services that doesn't suffer fluctuations of funding by intermediate headquarters, higher headquarters, or Congress. We should take a look at those programs to see what is different about them that permits them to go through the review process without the turmoil that some of the other programs seem to suffer. Is it the size of the program element that is involved, or is it the packaging of the program elements? Is it the coordination that is done among the Services within the program? Just what is it that permits them to seem to flow more easily and not to suffer fairly wide fluctuations?

The second recommendation was that perhaps we in OSD should consider having a laboratory management office that would look after the health and welfare of the administrative, personnel and other similar aspects of managing a laboratory. Examples of problems to be addressed include the current flap that we are going through with OMB Circular A76 and with the high grade ceiling problems. In the past, up until about eight years ago, we did have such an office within OSD.

But to the basic question of the TD participation in the S & T strategy, yes, they felt that there is more participation needed by them in formulating the overall S & T program strategy. They didn't quite know how to do it. But we need to think about this, and develop some sort of a mechanism to get them involved in the explicit decision making process, and to get some feedback from them. Mr. Gamota.

Workshop #2 Mr. Gerry Makepeace, Discussion Leader
Mr. Tom Dashiell
Dr. Lloyd Lehn
Mr. Bart Osborne

Topic The Proper Role of Advanced Technology Demonstration (6.3A) in the Research to System Acquisition Cycle

Objective To clearly define the nature and characteristics of ATD projects and assess their effectiveness as a transitional step to systems utilization of new technology.

Questions

(1) What technical purposes are served by ATD programs?

(2) Are they really needed, or do they merely add still another step to an acquisition cycle which already is too long?

(3) Are ATD programs a good way to pull out viable 6.3/6.4 technology from 6.2? Or are they just another way to extend the life of technologies which have served their purpose and should be buried?

(4) What criteria are used to determine when an ATD program has "succeeded?" What constitutes a failure?

(5) If ATD programs are useful and needed, how can their utility and acceptance be improved? If they are not needed, would other system changes be desirable to help the flow of new technology through the acquisition cycle?

MR. GERRY MAKEPEACE

Well, Workshop Two turned out to be quite a lively affair. There was very high interest on the part of all of the participants, I think. And the second day was no less lively and interesting than the first.

The basic objective of the workshop was to "clearly define the nature and characteristics of ATD projects and assess their effectiveness as a transitional step to systems utilization of new technology."

Now that is a lot of words, rather large words in a cluster, but I think it means something.

We spent quite a bit of time, as perhaps some of the other workshops did too, trying to define exactly what 6.3A ATDS really consist of.

Now it turns out that, of course, each of the Services has its own mode of dealing with this subject. Each of them has technology demonstration in a sense, but the point of view, the type of management, and, therefore, the definitions differ rather widely from service to service.

(Vu-graph 1)

Nevertheless, underlying it all, there turns out to be some unanimity of view, and I think some coherence. Now, what we have up here and this will be true of the remaining vu-graphs, is an underlying set of words written which were the conclusions of yesterday's group. Scratched over it and rewritten are some of the revisions that today's group insisted upon.

Today's group also added a number of bullets which may not be so clearly identifiable, but their contribution was more than just scratching out things that yesterday's group did.

At any event, it turned out that we could really define 6.3A only in terms of its purposes, as the panels could see them, and therefore the definition and the first question, which was, "What technical purposes are served by ATD programs," are melded together. We do have separate vuegraphs on them simply because we had too many items to put all on one.

Be that as it may, we found yesterday that Advanced Technology Demonstration consists of demonstration beyond the component level. That is one way of saying it. The group today, however, preferred to say "Demonstrations needed eventually" for the purposes of DSARC Zero which are too large and expensive to do under 6.2 Now that one can certainly be argued with, and maybe yesterday's group would argue with it. It is clearly understood by both groups, however, that there is not inherent in 6.3A anything that is tied firmly to a specific system development. That is where to get into 6.3B or 6.4.

NATURE & CHARACTERISTICS OF

ADVANCED TECHNOLOGY DEMONSTRATION

- o Consist of demonstration needed for DSARC.
- o Purpose to get data in support of *generic* systems.

  (Data potentially applicable to more than one specific end product)
- o Contain experiments for collection of data beyond laboratory scale
- o More flexible than 6.3B or 6.4
- o Can support larger blocks of technology than 6.2

Vu-graph 1

Secondly, and I think this is an important one, the purpose of 6.3A is to get data in support of generic systems. To get data rather than to define a specific system. Data potentially applicable to more than one specific end product. I suppose in some rare instances this might not be the case, but it has broad application. Certainly, unless an ATD is applicable in some way to some kind of end products generically, there is no use in doing it in the first place. So, it has that kind of a tie to that degree. In general it contains experiments for the collection of data beyond the laboratory scale, and that is a rather fuzzy discrimination between 6.2 and 6.3A. Much of 6.3A, insofar as we consider it a part of the S & T base, certainly could be part of 6.2. 6.2 could be expanded to the magnitude of 6.3A, but one could not swallow projects of this size without obliterating a wide variety of 6.2 projects. We can't do that, so I guess we have 6.3A as a crutch.

It has the characteristics of being more flexible than 6.3B or 6.4, flexible in the sense that it doesn't have to be tied firmly to a specific operational requirement before you begin. As I just mentioned, it certainly has to relate to operational needs eventually, but not by rigid paperwork to the same degree.

There are some differences between the Services on this, in the degree of tie that is presently called for and in the degree of overview by the system development people of the 6.3A programs. The Air Force is at one end of the scale, the Navy is probably at the other, and the Army is in between. But nevertheless, in all cases its flexibility is an important characteristic of 6.3A. Without it we really couldn't do the kinds of demonstration which the next vu-graph will show, things that we need.

(Vu-graph 2)

"Provide information confirming the usefulness of the technology and establish the level of risk." In general transitions to 6.3B and 6.4 appear not to take place. This is certainly not uniformly the case, but in general, they don't take place very readily -- unless in today's conservative full-scale development society the usefulness of the technology is rather firmly established, and the level of risk is equally firmly established.

"Define the costs characteristic to the technology, reliability, maintainability." These characteristics again are the sort that the program manager has to understand and have a pretty firm handle on before he will undertake or before he should undertake the application of the advanced technology to his program. The 6.3A program mechanism is one way of providing this information to him.

TECHNICAL PURPOSE OF ATD

- Provide information confirming usefulness of the technology
- Establish level of risk
- Define costs characteristic to the technology, reliability, maintainability
- Introduce new concepts that are foreign to users
- Stimulate industry IR&D for competitive position
- Provide window for selection of productive 6.2
- Establish confidence in readiness of technology

Vu-graph 2

"Stimulate industrial IR&D for competitive position." When 6.3A programs are performed, since they are in general fairly large-scale demonstrations, they are usually performed by industry, and when they are bid for by industry, one company usually wins. That particular company then is funded under the 6.3A program. If it is a technology of high interest, that immediately stimulates, shall we say, the rest of the industrial environment to see if it can remain competitive. To the extent that this happens, and it happens quite a bit in many program areas, industrial IR&D becomes then a more focused mode of transition of technology than perhaps it would otherwise be.

"Provide a filter for rejection of unproductive 6.2" was a choice that the first day's session made, and 6.3A certainly does do that. I think that is a very important function. I think all of us who have association with 6.3A would rate it as a function almost as important as the opposite one, namely proving technology that is indeed ready for use. The second day's session wasn't very happy with that kind of negativity and preferred to encompass both the negative and positive aspects in a single bullet, namely, "Provide a window for the selection of productive 6.2." Well, I guess depending on how you look at it, the glass is half full or it is half empty. They are trying to say the same thing in both groups, but by different mode. It eventually turned out by agreement of the second group that between the first day's session and the second day's session there really were no basic differences of opinion as to what ATD was, or what it should do, or what its purpose and utility is. But there was a lot of difference as to how to verbalize it. It is always a difficult process to verbalize something of this sort, and that entailed a great deal of discussion.

(Vu-graph 3)

"Are ATD's needed?" Well, I posed that question in as negative a form as possible, and I got a unanimous response and a most vehement one. The response of the first day's group was: "Yes, they are needed emphatically." The second day's group I challenged by saying: "Do we have to make this unanimous? It sounds like there will be nothing to argue about. There must be some of you who feel that it is not really necessary; that we can get by fine without it." Well, as it turned out, the reason for that wiggly underline under "unanimous" on the vuegraph is that members of the second day's group couldn't be budged. They are unanimous too. So, I guess the answer is a categorical "yes" which doesn't need any embroidery around it.

Another part of the question was, "Do ATD's merely add still another step to an acquisition cycle which is already too long?" Well, all agreed that the acquisition cycle is certainly too long; however, there was no feeling whatsoever in the groups of either day that ATD's lengthen the development cycle. As a matter of fact, there was a considerable feeling

ARE ATD's NEEDED

- Yes (<u>UNANIMOUS</u> conclusion)
- Role is parallel to the acquisition cycle

  ATD's do not lengthen but shorten the cycle!
- Essential to get new technology used
- Provide opportunity for serendipity
- Reduce risks of new technology application
- Provide focus for technology
- Provide opportunity for laboratory personnel to increase competence toward operational problems

Vu-graph 3

that they probably shorten it. I think there was again unanimity of both day's panels that ATD's aren't necessarily an integral part of the development cycle, but rather in most cases run parallel to it. Hence they are really inherently not in a position to lengthen it. They can feed information into the development cycle which provides confidence and gives a range of choice relatively early in the game. Therefore, it would come out in full-scale engineering development that they can and actually do shorten the development cycle in many instances.

Another support for the position of both panels is that it is essential, to do 6.3A in many cases -- certainly not all, but in many -- to get new technology used. It provides an opportunity for serendipity. That is a very interesting statement. One of the things characteristic of our present day's DoD Research and Technology and Research and Engineering Programs has become a rather rigid format and, particularly as we get down stream from 6.1, rather more and more a hesitancy to take risks, to look around and see how things interact, and -- when you discover that they interact in ways totally different from what you had any anticipation of at all -- to say, "Well, maybe we could do something with that," and to spend enough time and effort to find out. Occasionally, by this means we have discovered something really important. In research, I think, that still goes on freely, but farther down stream it doesn't, and only farther down stream do you have enough interaction of components and enough interaction of systems and subsystems under test to realize the particular kind of serendipity that is important to engineering technology.

Well, 6.3A does have enough flexibility, so it was a feeling on the part of members of the group, and I think that is true of both days, that insofar as such opportunities can be provided in today's DoD society, 6.3A is a mechanism for doing so.

"Reduce the risks of new technology application." Well, I think that is pretty clear and we have discussed it enough.

The next item is: "Provide a focus for technology." We didn't have an opportunity to discuss this at sufficient length to be certain that we were all in agreement on it. During the second day, we got to it in the last five minutes or so. What I think it means is to provide at a level approaching end use consideration a tight focus upon what technology is useful and what technology is not useful, potentially or presently, and thereby to feedback to the 6.1 or certainly the 6.2 level more concentrated attention to those things which look to be really important. Insofar as it does provide that increased focus, it also provides a very useful guide, which is probably not otherwise readily available, to which technology should be stressed for 6.3A demonstration in the future.

"Provide an opportunity for laboratory personnel to increase competence toward operational problems." To the degree that laboratory personnel are involved in 6.3A to a greater extent than they are in full-scale

engineering development or pre-engineering development -- and I think perhaps this is true more in the Air Force than it is in the other two services -- certainly the 6.3A program does provide an exposure to realities at a level that might otherwise be not very readily accessible. Exposure to reality is always a good thing for laboratory personnel.

(Vu-graph 4)

"Are ATD programs a good way to pull all viable technology from 6.2?" Well, coming back to the earlier decision, "yes" applies here too, but as I think was appropriately and at some length discussed, it is certainly not the only way. In some cases direct transition will take place from 6.2 to 6.4, frequently from 6.2 to 6.3B. Where direct transition can take place, it should. Under no circumstances, should we ever formalize the 6.3A type of program in a fashion that locks us into a system and requires that everything must pass through it. The instant we do that, or even contemplate doing it, its value is largely destroyed. At that point, it then does become an addition to the acquisition cycle. Its parallelism and the fact that you use it when you need it, and you don't use when you don't need it should be retained at all costs.

"Can ATD's give definitive answers and dispose of technologies?" Perhaps we covered this sufficiently in earlier comment.

(Vu-graph 5)

The criteria for success. "What criteria are used to determine when an ATD program has succeeded, and what constitutes a failure?" Here again, there was a very strong view, and it developed to something that I believe is complete agreement in both days. "Success" takes place when information is obtained that is desired as clearly defined in the test guide. "Failure," to move to the bottom of the vuegraph, takes place when answers to the questions which you have set out to answer are still undetermined after the tests are over.

This is to clearly discriminate success in an ATD from the kinds of things that constitute success in a pre-engineering development or engineering development program. There, success consists in coming up with a successful product, and failing to do so is clearly failure. Well, in 6.3A that isn't the case, and that is what makes it the end of the S & T cycle rather than the beginning of the engineering development cycle. What we are still looking for here is information. We are not looking for a piece of hardware which by definition has to work and will be plugged into a 6.4 development program.

Success certainly also takes place when you amplify that by finding that technology is indeed ready to accept or that the laboratory directors are ready to reject. It dirscriminates, as we said a moment ago.

ARE ATD's A GOOD WAY TO PULL OUT
VIABLE 6.3/6.4 TECHNOLOGY FROM 6.2

- Yes they constitute a good way (but not the only way)
- Where direct transition to system application is possible then it should be done
- They can give definitive answers and dispose of technologies

Vu-graph 4

CRITERIA FOR SUCCESS

- Information desired was clearly defined and tests obtained it.
- Users find technology ready to accept

OR

- Laboratory directors are ready to reject

FAILURE

- Technology questions are still indeterminate

Vu-graph 5

(Vu-graph 6)

Now, "If ATD programs are useful and needed, how can their utility and acceptance be improved?" That was the question. There was also a counter question, "If they are not needed, what other system changes would be desirable to help the flow of technology through the system?" Since both groups agreed unanimously that ATD's are needed, we only considered the first part. The question of getting better acceptance for them and of proving their effectiveness brought about a great deal of discussion. We tried to consolidate as best we could, and we could have used another hour or two, on the part of both groups, to really give this the degree of work that it probably should have.

There was however a unanimity of opinion that management and control of the funding for 6.3A should be under the S & T community, because it is an essential part of the S & T process; it is not a part of the pre-engineering development process. Insofar as it is under the S & T community, it will be treated as a part of the technology process which is

important and which has relatively high priority. We are never going to do all proposed ATD's, but nevertheless, they are going to have relatively high priority, because they are the realization of the S & T process. If ATD's are instead inherently a part -- as they are in some of the services to some degree now -- of the pre-engineering development and engineering development cycle, then they will have the lowest priority almost by definition, because they aren't yet tied to something that has an immediate requirement set up for it as a product. To the extent that 6.3A isn't specific product oriented it then becomes a kind of bank for money that 6.4 programs require at higher urgency.

Now, as the other face of bringing the management and control of funding for 6.3A under the S & T community, there is a very important requirement to provide for more participation and review for potential users, which means both the ultimate users in the operational community and also development program managers. Bringing management of 6.3A from where it now is in the Navy, for example, as a part of the pre-engineering development process, and putting it into the S & T process does have the disadvantage of creating a different transitional boundary that has to be crossed. Now to the extent that may be the case, but perhaps in any case, it is especially desirable to get as much participation and review by potential users as we possibly can, and that will certainly increase the acceptance of new technology and its utility as well.

"Better definition of objectives of ATD programs." Well, as we mentioned a moment ago, the failure of one constitutes a failure either to define clearly what you wanted in the way of information or failure to get that information. Unless you define an ATD accurately, you will almost certainly build in a failure. When you started with a precise definition, you have given yourself a good chance for success.

HOW CAN ATD UTILITY AND ACCEPTANCE BE IMPROVED

- Bring <u>management and control</u> of funding for 6.3A under the S & T community within military departments.
- Provide for more participation and review by potential users.
- Better definition of information objectives of ATD programs.
- Retain or increase the flexibility provided by 6.3A.
- Define 6.3A interface with manufacturing technology.

Vu-graph 6

Workshop #3 Dr. George Millburn, Discussion Leader
Capt. Frank Austin
Col. Bob Poppe
LtCol. George Kpocsak

Topic Forecasts for S & T Breakthroughs; Strategy for their Pursuit.

Objective To optimize the environment for achieving science and engineering breakthroughs and to determine the means for realizing that environment.

Questions (1) What are the essential ingredients to achieving the environment for breakthroughs? -- is it optimized today in our S & T program? Evaluate best predictive and assessment approaches for S & T breakthroughs -- what specific factors impede breakthroughs?

(2) What are the strengths and weaknesses of a structured environment (e.g. as in industry and in-house laboratories) and unstructured academic environment.

(3) How does one identify science and engineering (S&E) ideas that have the most potential? Cite examples of S&E areas offering attractive potential breakthroughs.

DR. GEORGE MILLBURN

The workshop started off by attempting to define what a breakthrough was. We had a little trouble with that. But I think that by and large we agreed that a breakthrough was something new and different, preferably sudden, and that in some cases they could be planned.

One person, to use the example of fission, said the discovery of fission was obviously a breakthrough; the resulting development of the nuclear bomb was not. However, there was further discussion supporting the point of view that there were planned breakthroughs. For example, an important question was: is more than one neutron emitted during the fission of a uranium nucleus? There was an experiment done to determine that nu, indeed, was greater than one. Getting that number was a breakthrough from some person's point of view. Being able to do the isotope separation was another breakthrough that was, in a sense, planned and programmed.

One of the questions that we addressed was what are the essential ingredients to achieving the environments for breakthroughs? There was general agreement in this case that a requirement is some degree of stability within the laboratory. This is stability in a sense that people do not feel threatened, that they feel comfortable in their environment; and not stability in the sense that all of the work is programmed for them in great detail.

The people, it was agreed, are the important characteristic for developing breakthroughs. There was some discussion yesterday that by and large the younger people were more capable of developing breakthroughs. There was, this morning disagreement with that point of view.

There was general agreement that it was very important not to expose a potential breakthrough too early in its development, that these concepts needed protection. They had to be nurtured out of sight of the critics who would say "No, that makes no sense; it is not in your mission; it is not in your budget; don't do it."

There also was general agreement that it was important that the laboratories have some leeway, some discretionary funds or some discretionary resources, which they could apply as they saw fit to an attempt either to develop a breakthrough, or to exploit one once it had been developed.

This morning two points were added to the summary of the group discussion yesterday: One was that the innovators, the people who by and large come up with breakthroughs, are to a certain extent identifiable, and should be nurtured and separated from the more mundane tasks of the laboratories, and should be given recognition for their achievements.

A point that was emphasized this morning, and also to a certain extent yesterday, was that an important source of motivation for developing

breakthroughs is interaction with the users. with the people who actually have a problem. If the laboratories have a mechanism for getting out and talking to the using commands, this somehow tends to motivate and generate breakthroughs, rather than working in an isolated environment.

The second question the workshop addressed was the strengths and weaknesses of a structured environment, for example, as in industry and in-house laboratories, and an unstructured academic environment.

I think there was general agreement both days that the academic environment is also structured; in fact, that there is probably no such thing as an unstructured environment. There was a general feeling that more discretion for the application of resources existed in the academic environment. I think the implication also was that the resources could be shifted more quickly. To that discussion of yesterday afternoon, which was generally concurred in this morning, was added that it is important to have positive technical support, again, primarily for the people who are working in the environment, and who are attempting to come through with breakthroughs.

By far the most difficult question was the last one: *How does one identify science and engineering ideas that have the most potential, and cite examples of science and engineering areas that offer attractive potential breakthroughs.*

This borders on the question of can you or can you not forecast breakthroughs. There was general agreement that they cannot be forecast, they cannot be scheduled. On the other hand there can be areas in which breakthroughs are required before we can do certain jobs, perform certain missions. They can be clearly identified, and in some cases even programs set out with an objective of achieving a breakthrough. But forecasting them, scheduling them by and large was rejected.

We attempted to generate examples of areas that are ripe for breakthroughs, and we came up with a total of approximately seven:

One area is adaptive optics. The primary justification for this came from the high energy laser program, and attempting to solve the problem of propagating high energy laser beams, through different media. But it appears to have applications to other areas also. That, in at least one person's opinion, could be termed a potential breakthrough.

Another area was reduction of cross sections, both optical and radar; it would make the task of detecting missiles, primarily, much more difficult.

Another area was the need for nonnuclear electromagnetic pulse generation. It is very obvious that if we can't do nuclear testing, we cannot generate electromagnetic pulses by nuclear tests any more. The development

of a nonnuclear test mechanism was considered to be a potential breakthrough area.

A similar area is nondestructive evaluation, or nondestructive testing. The primary motivation was from the materials specialist in the group to test materials nondestructively. But it was immediately generalized by some of the medical people, to include nondestructive examination and evaluations of medical problems. And clearly it is very important there.

There were two suggestions by the medical people for potential breakthrough areas, one in the area of biomechanical modeling. This is very important from their point of view, again, of trying to understand effects of nuclear radiation, or other types of radiation, on living mechanisms.

One thing that was bothering the medical people a great deal is the requirement they have, imposed by Congress, to identify materials which are carcinogenic. And there is such a long list of these materials, that to do the testing and feeding of animals over a period of a year or two and decide which ones develop cancers is so expensive that there is not enough money in the budget to do it.

To that list of six was added this morning the area of superconductivity at relatively high temperatures, up to 70 degrees Kelvin, which avoids some of the problems of cryogenics, and perhaps could make the application of superconductivity more widely available within the DoD environment.

Workshop #4 Mr. Len Weisberg, Discussion Leader
Mr. Ray Thorkildsen
Cdr. Paul Chatelier

Topic The DoD S & T Infrastructure: What should it be and how should it be supported?

Objective To define the S & T Infrastructure and to evaluate its importance in an effective overall DoD R&D program.

(1) What is today's S & T Infrastructure -- Is it adequate?

(2) Identify effective methods for keeping the infrastructure program fresh, imaginative, and truly productive.

MR. LEONARD WEISBERG

I think our workshop was a little different than most of the others. The vu-graph shows the question that was asked. But before we could even address the question, we had other problems.

The first problem was that no one had even heard of the word "infrastructure" nor knew what it meant, and we started from that point. After they began understanding what in fact it meant, they said, "What is the point of inventing a new term which is confusing and unnecessary?"

Even further than that, they said, "My God, this is the worst thing you really want to do," and states that they must go through their operational type people who emphasize mission and immediacy. They have learned the lesson very well and very dearly that they have to relate their programs directly to mission areas and they see the concept of "infrastructure" going in the opposite direction. In fact, some people have gotten calls from Congress asking questions about $150,000 program and saying, "Exactly why are you doing this, and what system would use it?" So both groups felt quite strongly, and incidentally the 6.1 people felt this even more strongly than the 6.2 people, that the end result would be to make programs harder to defend and would probably result in cuts. I did want to bring out these concerns.

Furthermore, to add to this, they said it would add constraints on managers and would make Zero Based Budgeting more difficult, and perhaps create additional meetings and reviews. In the 6.1 community there were some comments that they now have a system working, and since the whole 6.1 community is considered to be infrastructure of programs, why do we need to get another structure to work within the 6.1 community? I think that is quite a legitimate thought that whether infrastructure really applies mostly to 6.2. Also the point was made that it may not apply to all areas, specifically the life sciences where they have been asked an awful lot of questions on programs which interrelate to the civil sector and whether this would add to that problem.

Going from this point, now we will start addressing the two questions that were originally raised. The top definition is the one that Dr. Davis presented to the group yesterday morning, and still that didn't seem to fully convey what the concept was to people, and a few points were added in coming up with another definition. The first few words indicate that these are a set of programs that are selected. The next few words imply that their infrastructure quality did not come about by accident. These are intentional programs that we state are infrastructure programs. Then the next few words are about the same: "To provide a technological foundation or underlying structure." But then the final few words state something that Dr. Davis had in the same slide, but to emphasize the fact that the output should be applicable to a multiplicity of systems. Even though that was implied, it was felt useful to make it explicit.

We tested some of the programs that Dr. Davis had listed yesterday against this criteria, and they seem to meet. 6.1 seemed to fit that criterion. There was some confusion that we had broken out programs in three categories: infrastructure programs, incremental, and breakthrough, and whether these are mutually exclusive. I am referring to bullet number two. The answer was, no, an infrastructure program can be incremental or breakthrough in nature.

Another question was do we look at a whole bunch of our programs and pick out the bits and pieces that may be part of an infrastructure and identify those separately? Again bullet number one addresses that. The answer is no. An infrastructure is not bits and pieces of many programs, but it is a set of programs that we identify as feeding into other programs and by themselves are an identifiable set.

The question also arose: can they be mission-oriented or not or should they just not be mission-oriented? In going over some of the programs, some are and some are not. This by itself is not a criteria. And furthermore, they can be either long range or short range, such as integrated circuits in some cases are quite short range, but integrated circuits still provide an infrastructure.

Again, we don't mean programs that accidentally have fall-out, and then say "hey, that is infrastructure," but do, in fact, mean identified at the start as infrastructure programs.

We cannot forget the fact in the DoD system that they must be potentially relevant. That is, instead of immediately relevant, perhaps, at least potentially relevant to a mission or a threat; that they address some threat area.

After going around and back many times on what the utility of considering infrastructure programs to be, especially remembering the comments I discussed in the beginning, (that people saw these hurting the system and taking a step backwards) the key point was made that we have seen infrastructure programs in many cases being difficult to defend because they are more difficult to relate to a specific mission area, and are frequently given lower priority within a laboratory. That is, they end up being out if one is looking for places to cut programs.

Also they may not be appreciated by upper management, as I mentioned, both in the Service command chain, and also in Congress. If, in fact one realizes the need for these to be appreciated and understood by people, then one realizes the value of a tool that could allow certain programs to be changed in their evaluation.

One of the effects of introducing the concept of an infrastructure is that it could serve to help sell programs. Again, there is a big question mark whether this is going to be positive or negative within our particular system.

Second, you could raise the priorities of these infrastructure programs, or you might even identify these as broad defense programs that otherwise might be in jeopardy.

The concept of infrastructure might not be useful for all areas. Perhaps we should pick out those programs where it would be helpful and useful to indentify them as infrastructure programs, rather than lay it on as an entirely new structure that people have to formally use through all of their program evaluations.

Finally, concerning recommendations and answering the second part of the question, how should this be supported as a concept; the following recommendations were proposed by the group. They have not been prioritized, but they are separated in different categories.

The first recommendations is that if you are looking at infrastructure programs, you should really separate them from other programs in your prioritization process. That is, going to bullet number two, you really shouldn't use the same criteria for infrastructure programs, because if you do that, they will end up at the bottom of the list.

For example, one might prefer to use the state of the art rather than direct relevancy as a criterion or, maybe, talk about 1990 needs, instead of 1980 needs. These are comments that came out.

Second, to help infrastructure programs, you should try to give them a longer term support, realizing that they feed into a lot of programs, and realizing that they can affect a lot of different goals. It makes less sense to have to continually justify them than to try and support them on a broader, longer term basis.

The next recommendation is the concept of not having the technologist address the end use. If you separate the technologist too much from end goals, you have the danger that his work will become less effective. To do that, you should involve the technologist in defining the threat environment, to understand the real world as it exists, and what some of the constraints are.

Incidentally, my own feeling here, as I view programs, whether they are infrastructure or not, is that this is a major problem in technology. When the technologists do get involved with defining the end use and really understand the constraints, their work frequently becomes much more effective, and it sometimes stimulates the imagination and increases creativity.

One should still define a relationship to the end user. Furthermore, by taking an infrastructure program and relating it to a series of end uses, one could better justify the programs, rather than trying to relate it to a single end use.

There are a few other final comments. These just include reinstituting REFLEX; increase the use of the visiting scientists; hold tri-Service topical reviews emphasizing these infrastructure programs (because in fact they should be typically tri-Service in nature) and perhaps use advisory committees or TCPs as other tools.

However these were questioned by the group on the second day as perhaps just providing more work and accomplishing very little in the system.

Even though there was a constraint that we wouldn't talk about problems like this, the second group asked me to present this because they felt it fit into the concept of infrastructure. They feel the real infrastructure is the resources and people. And the single main constraint that they would rather see changed than almost any other in terms of improving our intrastructure programs is to raise the restrictions on hiring GS-13 to GS-15 people.

Workshop #5	Dr. Peter Franken (University of Arizona) Discussion Leader Dr. Tom Walsh Mr. Ed Myers Dr. Bob Lontz
Topic	The Military Research Forefront: What current areas comprise it and how can they be supported?
Objective	To identify effective methods of forecasting future DoD high priority research areas.
Questions	(1) Can we today identify future high priority DoD S&T areas--if not, should we be developing methods to improve our forecasting methods? (2) How does one determine the break-even point--to support or not support an area of research. (3) How to improve technology transfer from research to exploratory development.

The conclusions of the workshop were discussed on 25 July with the full conference group in the form of nine brief statements upon which I dilated during the 15-minute presentation. Let me append these statements below with some of that discussion, keeping in mind that the workshop had not assigned priorities to these conclusions and that the statements do represent a consensus of the participants.

1. BY AND LARGE, FOREIGN R&D SHOULD NOT DRIVE U.S. BASIC RESEARCH. (UNLESS, OF COURSE, THEY HAVE A GOOD IDEA).

   The important message here is that the priorities in our basic research (6.1) endeavors have too often been dictated by perceptions of Soviet activity rather than an assessment of the health of the United States efforts. The group as practical political chaps recognized, of course, that once some programs requiring further support have been identified it is often necessary to use arguments relating to Soviet activities to accomplish internal funding objectives.

   An interesting example is the high energy laser program which was featured in a number of comments made during the plenary session of conference itself. It may well be true that the Soviets are spending half a billion dollars equivalent on their high energy laser program. However, the decisions made by the United States defense establishment should be primarily driven by our assessment of the health of our own endeavors rather than the assessment of Soviet enthusiasm and/or panic.

2. WE SHOULD NOT TRY TO IDENTIFY LOW PRIORITY RESEARCH PROGRAMS. HOWEVER, WE MUST CONTINUE TO ASSESS THE QUALITY OF RESEARCH PROGRAMS.

   The concern here is that in the 6.1 arena it is very dangerous to utilize priorities in the sense of identifying areas of low concern. There are, of course, some topics simply not pertinent to DoD missions, e.g., cosmology. But working within the technology base of current DoD endeavors it is very risky to identify an area of low priority because this will almost automatically become a self-fulfilling prophecy if funding and resources depend from the priority establishments. Historical prospective constantly provides us with examples of "breakthroughs" occurring in research endeavors that, prior to such breakthroughs, were considered to be of low priority or relevance to DoD objectives. The other side of this coin, however, is the absolute necessity to continue assessment of the quality of the 6.1 programs. The results of such continuous assessment is what should provide the major indicators for whatever modulation of research support is undertaken.

3. SHOULD THE PRESIDENT BE BRIEFED ON THE ANNAPOLIS CONFERENCE? NO.

The workshops probably spent more time addressing this question than was intended when the assignment was suggested. The reason for the unequivocal conclusion is primarily that the desirability of burdening the President with a 15-minute summary of an executive summary of a report of a conference just seems terribly ill advised. The President should always be briefed about specific matters of substance, emergency or high priority and, of course, needs to be provided with contextual materials pertinent.

4. A REPORT SUCH AS THE ANNAPOLIS CONFERENCE IS LIKE A BUSINESS PLAN: MAKE IT BUT DON'T USE IT.

Most successful American companies do go through the exercise of creating business plans, often for a forecasted five-year period. The discipline of forcing the company people to examine market place, technology, resources, etc. is an extremely valuable exercise itself. Companies often get into difficulties, however, if they then take the business plan itself as the important product and utilize it. A good business plan begins to develop error immediately after its production and those companies, or government organizations for that matter, who have tended to stick to a plan attribute gospel qualities to it with which the product is by no means endowed.

5. IF WE COULD INDENTIFY HIGH PRIORITY RESEARCH TOPICS FOR 198X, WE WOULD WORK THEM NOW.

This observation is directly related to the activity of an individual researcher. If he can think of excellent research that he would want to work on in 1982, of higher priority in fact than what he's working on now, he will make every attempt to switch topics immediately!

6. FORECASTING RESEARCH NEEDS AND PRIORITIES IS VERY LIKELY IMPOSSIBLE, AND CERTAINLY ILL ADVISED, E.G., TRANSISTORS.

This statement is very pertinent to 6.1 endeavors and, correspondingly, somewhere between misleading and unsensible for exploratory development and 6.3 efforts. For the 6.1 arena, however, history constantly provides us with examples of dramatic changes in contemporary technological assessment brought about by very unexpected and unanticipated "breakthroughs."

The transistor example is worth some mention. In the mid 1940's, right after the war, technological forecasting by the community vis-a-vis electronics was towards an emphasis on materials and manufacturing techniques for producing more compact as well as multifunctional vacuum tubes. The development of the point contact transistor a few years later introduced an absolute revolution into

electronic speculations. However, it should be recalled that the thoughts then including notions espoused by Dr. Shockley and his colleagues, were oriented to the application of point contact transistors to those problems where the very low power levels that could be handled with that technology could be exploited, e.g., pre-amplifiers. It was asserted that the transistor could never replace most of the electronic accomplishments provided by vacuum tubes simply because it was very difficult to imagine any power level significantly higher than 100 microwatts becoming a possibility.

Then a few years later came the dramatic development of the junction transistor and modern electronics entered its new age.

The workshop groups felt that the message in this example was vivid and should not be forgotten during exercises pertinent to the development of forecasting techniques. Had the Bell Telephone Laboratories some 30 years ago assigned their basic research resources according to the then current assessments of electronic technology, it is both amusing as well as somewhat frightening to think of what the consequences might have been.

7. BASIC RESEARCH IS BEST MODULATED AT THE PROJECT LEVEL BY PEER PROCESSES RATHER THAN BY DOD MANAGEMENT.

Peer processes include not just review of proposals and the like but the all important effects of interactions within the research community itself. Research of good quality often manifests itself in the extent to which the principal participants in a project are embraced by professional activities of their colleagues. For example, invitations to present results at major conferences, manuscripts accepted for publication in major and refereed journals, etc. The research community itself, of course, has made mistakes in this respect particularly when research results have been communicated in an unorthodox fashion. However, the track record of the scientific community correctly identifying important research early in its progress is very good. The sense of the group's recommendation is simply that these peer processes are likely to be far more satisfactory in determining the level of support for particular projects then will be provided by the DoD review and examination. The group does not recommend DoD abdication of responsibility by any means. The emphasis in this recommendation is simply to urge DoD management to utilize the peer processes more substantially in the assessment of specific 6.1 endeavors than they often appear to do.

8. GOOD RESEARCH PROJECTS NEED PROJECT CHAMPIONS RIGHT THROUGH THE TECHNOLOGY TRANSFER PROCESS.

There is a very important notion here because the workshop did perceive the trend over the past decade or two of 6.1 being conducted

more and more in response to RFQ's rather than the response of DoD to unsolicited proposals. As an example of a desirable procedure the group considered the process whereby an individual or a group within a company, for example, puts forth an unsolicited proposal for research activity in a particular program of their invention or their own enthusiasm. If the work meets the standards of broad relevance to the Department of Defense and the proposal itself is of high quality, judged by current standards, then a response to those "champions" is strongly indicated. These people pushing the project from within the company itself are going to make very sure that it receives support and they will certainly guarantee that any success at all will receive recognition both from within the company as well as the DoD itself. An additional point here is that the company and its champions will also push for the technology transfer process because of the proper company motivations themselves. It is a lot easier for a company to convince a military Systems Command to explore the utility of a new technology than it often is for the OXR's themselves.

9. IF RESEARCH FORECASTING WERE PERFECT WE WOULD NOT NEED 6.1.

This seemed self evident to the group.

Conclusions.

The workshop was not as derelict as it might seem in addressing the itemized questions provided it by the conference sponsor. In particular, the question of whether we should be developing methods to improve our forecasting methods was discussed throughout the sessions and the response varied from an absolute NO to substantial doubt. The notions that emerged essentially as a consensus were that forecasting in the 6.1 area can provide for self-fulfilling prophecies that are against the very interest of 6.1 itself. The transistor example comes to mind.

A second point about forecasting is the essential impossibility of it when it comes to the identification of future "breakthroughs." The workshop felt it was most important to continue forecasting techniques in 6.2 and beyond, so that the very strong conclusion expressed must be identified with 6.1 efforts alone.

Another observation made several times, in one form or another, is that technological forecasting in general is very easy for long times such as 30 years, or short times such as 3 months. It is very tough, however, in the 2 to 5 year time frame.

Workshop #6 Dr. Bill Nierenberg (JASON), Discussion Leader
Mr. Andy Aines
Mr. Ray Standahar
Col. Joe Friday

Topic What S&T strengths are now available to DoD from academia and industry?

Objective To identify and maximally utilize the stengths from academia and industry in improving the DoD S&T program.

Questions

(1) What fraction of your programs originated from ideas from academic or industrial researchers?

(2) Are the goals of programs supported in academia defined well? --- should they be if we are to increase innovation?

(3) What weaknesses exist in academic or industrial R&D and how should in-house laboratories fill these gaps?

(4) Can IR&D programs be complementary and be integrated in a constructive way in the DoD S&T program?

Let me start by making a remark that I am really very pleased to have been here and meet really such a distinguished group. It is quite extraordinary to meet all of this group at once that is so responsible for technical strength in this country. I must congratulate Ruth Davis for this idea. I hope it gets developed to its fullest possibilities in the future.

With regard to the work in my workshop, I would like to put it this way. We had four questions, and I think I can only possibly answer one on behalf of the twenty or so people I was involved with. That was question number four which is, "Can IR&D Programs Be Complimentary and Be Integrated in a Constructive Way to DoD S&T Programs?" As far as I can make out, the answer to that is, yes. That is one question we can answer.

Now as far as my reporting overall goes, I would like to make some very general remarks. Perhaps the other group leaders will be making similar remarks. The general question which is, "What S&T Strengths Are Now Available to DoD From Academia and Industry?"

Addressing that question for all of us was a very complex task because of the significant differences between the services and their laboratories, and the different missions makes it very difficult to universalize. I should say something, of course. Academia and industry may view their strengths and weaknesses differently than as seen by the laboratory directors.

I would make my response in three parts. The first is just the very gross results of the discussion as I saw them. The third one is the topics that were not suggested in a natural way, but could have been, and did come up. Then the second, the bullet comments that we could possibly agree on with regard to all three organizations, industry academia, and DoD labs, in the sense we are discussing.

As far as the gross results go, the labs vary a great deal. In fact, there is an objection just on this basis to calling them laboratories as such. They vary, and their optimal use of industry and university vary a great deal depending on the discipline that is involved in the service. The area of development of tanks is an example that concerns the Army. The universities apparently are of very little use there, whereas, in the case of environmental sciences, atmospheric sciences, the oceanographic sciences, and the earth sciences, universities are very inportant and in many ways key. So it is very hard to generalize just on this basis.

It would seem that the laboratories show a very great ingenuity in achieving the best cooperation and results from either industry or the laboratories. But of course they each have to do it in a very different way depending on the disciplines and depending on the mission that is involved.

There seems to be very excellent understanding of the possibilities, and the labs do seem to make very excellent use of them. The one thing that came through to me was the external constraints that the labs have learned to live with. There are the personal service regulations, if I say it correctly.

I was unaware of how pervasive these regulations are and how difficult they are for the lab directors. I knew only a very limited aspect of how it does seem to be a hinderence to lab directors to be able to make full use of the universities or industry. Depending on how they do it, there are devices for getting around it, but those would hinder some of the advantages of the laboratories. These are the generalizations.

There was one more thing that did seem to come up that might have been programed in a little better. There are intellectual sources available to the DoD laboratories that are very important that didn't come into our discussion. For example I refer to the old NASA in aeronautic cases, NOAA in the sense of environmental problems, and so on. These somehow have to be treated if you want to get this into a balanced discussion.

If I jump over the second item and go to the third, for "ideas" and points that were surprisingly unmentioned the first time, I am talking about the sort of new idea, although it is done, that would be very important to the laboratories -- to have a formal exchange of senior people between labs and universities.

Now this is done to some degree in some of the laboratories, but this is meant in a somewhat different sense than what is happening now. The workshop was not talking about post docs. The suggestion really referred to senior people, for an extended period of time. The belief was strongly held that many faculty would be pleased to be involved, particularly because of the special facilities available in the laboratories.

The other point was made, that at least for those laboratories that haven't had as much success in dealing with universities as they would like, that perhaps not enough effort was put into developing the specific relationship. Some of the directors felt that one has to expect to put in more effort in developing a relationship with a specific university in specific areas than might be anticipated in comparison with developing a relationship with a specific industry. I mentioned the special area of the environmental services.

Then of course there is always a thing we must remember. We all know that the laboratories and the universities play a very special role jointly for somewhat different reasons. They do represent what I quess people like to call the corporate memory. I call this the maintenance of essential technologies that have to be kept alive even though there is no specific hardware procurement related to them at the moment.

I must bore some of you, but perhaps not others, with a favorite that I have been involved in, which is high powered sonars. We have never

really built very, very high powered sonars, but we are always on the verge of doing it, and knowledge of how to be able to do it is very important to be kept alive. The universities do it, you see, because of tenure. That is one advantage of tenure. An old professor who perhaps is not being supported but keeps chopping away at the one only thing he knows.

The government laboratories of course do it very often by intent, and proper intent. I should say that the last time I made this speech somebody said, "You are absolutely right, Bill. But it can be overdone. Do you suggest that some of the Army labs should maintain expertise in cavalry?" So I quess everything requires judgment.

Now the unmentioned points. An example that I just don't want to make much of, was the question of production of personnel, development of scientists to feed the machine. Presumably this is something above the realm of the laboratory directors.

Nobody really seemed to feel, surprisingly with one or two exceptions like chemical or biological warefare, that the laboratories or their representatives were unwelcome on campus. That doesn't seem to be an issue, and I agree.

Then there is the broad question of advertising the DoD problems. I was a little naive there. I thought that was the special problem for the universities, but some of the people felt that in the area of 6.1 research there was even a problem where industry was concerned -- that one could do much work there.

Now in the few minutes I have left, Mr. Chairman, I would just like to run through the bullets that came. These are not my comments, I hope you remember, although I removed some of them after today's session.

Let me start with industry, the strengths and weaknesses just as listed: Have excellent systems capabilities. Even that was debated as a definition. They generally meet their deadlines. This is a crack at universities. They have manufacturing capability and can follow up on products. They can quickly assemble know-how, especially if they see product delivery in the future. They are driven by the profit motive, although I don't know why that is a strength.

Particular industries have very much to offer in the sense of technology. The presumption is some industries don't. The weaknesses that were listed by the group are: Even if they have theoretical knowledge, they don't see long-term productive possibilities. Their interest wanes very rapidly. If they don't have specific in-house know-how, this is a debated one, they often will not bid on the project. What is meant here is that where the government manager might think that the components exist in a particular company, the company may not bid if they feel that the effort of putting together the team is just too much. Then the question

of patent and proprietary problems was raised and I wasn't very clear about that, and neither was the group today.

You can thank Jim Probus for this one, he really makes the DoD laboratory sound very good. The points that I collected from the group without him, was that the laboratories provide for continuity and know-how. They have the ability to contract out and evaluate themselves, with good residual, empirical, and theoretical work, and considerable dedication and talent in the laboratories. All of which I agree with.

Of course, they are available for fast response. Al Bermen was available to the President of the United States to get quick answers on sonic booms, as an example. They have, and I made this point, very important special facilities that they maintain that are essential.

In the case of the Navy labs and to some degree the others, they exist for direct fleet support. A very important point is, of course, that they have access to proprietary information and special intelligence, and there is really no other good way to introduce it in the system. The laboratories do have good systems capabilities that complement those of industry.

The weaknesses that were listed may make it interesting to those of you who weren't present at these sessions. Civil service regulations make it hard to purge dead wood; not sufficiently successful in getting rotation from industry and academe; often afflicted with overmanagement from above; can improve communication processes; accent may be on creating new knowledge rather than exploiting it; excessive paper work reduces time of bench scientists; too much layering and justification reduces spirit of innovation.

I want to make a comment here. The group this morning objected to quite a few of these points. They felt that they weren't correct. But I pointed out to them that this was a fair longhand copying down by two of us of comments that were made by another group of lab directors yesterday. Furthermore, I have heard them in other places and at other times, whether they are correct or not.

The strengths and weakness of academia were listed. They do best in theoretical and limited empirical work, and also in muddling. There is a large pool of graduate students available in the United States and also many willing faculty members. Incidentally I think it was meant that they are availabe to serve on panels and as advisors to laboratories and the directors. They possess good computer software capability. That was mentiond quite often. They contribute to helping students enter the real world and a knowledge bank for future needs. They are proficient in evaluation and analysis, and provide a large reservoir of knowledge.

In most areas, except chemical and biological warfare, their willingness to participate in DoD programs is becoming apparent. DoD can use the support of academia, and the continuity which I wrote in to supplement

my earlier remarks. The weaknesses: In the 6.2 areas where there are time constraints, they do not do well. They don't do well if products are involved. There are certain specific areas, like computer aided ship design and tanks, and I said earlier where they just don't seem to be making any instant contribution.

Congress has been critizing the university in recent years for rapidly and spectacularly increasing overhead charges to the point where they are questioning whether the university research really is cost effective. They found in the Themis Program, that the dollars were being used to help foreign students. That was a curious and interesting comment. Although the Mansfield Act "spirit" is diminished, NSF appears to have the responsibility to assist universities. If required to give geographical dispersion to universities, the quality of the results may be watered down. Now of course I don't know why that makes universities different from industries, but the comment was made. Well, Mr. Chairman, I have probably taken my full allotment of time now, and this summarizes the report.

CONCLUDING REMARKS
DR. RUTH M. DAVIS

DR. RUTH M. DAVIS

I sincerely thank you again for being willing to come and participate, and by that I mean being willing to talk with us and give us your ideas.

This particular meeting had its menu set by us, and I specifically tried to make sure that we didn't advertise or even promote it as a meeting to discuss the problems of technical laboratory directors. I needed to meet more of you, and you needed to get to see us more in an institutional manner. Also, I felt that the kind of topics we should be discussing in a first-time environment should be those for which we have the responsibility in the Department of Defense, namely the DoD Science and Technology Program.

To make that program successful, there are a number of problems and issues different from the ones on your menu that must be resolved. The problems and issues that you saw, 6.3A, infrastructure, and the like, were the ones that primarily concern my office. It is my intention, in line with Bill Perry's and Harold Brown's desires, that our office, R&AT, be an active rather than a passive office in setting the right environment for the DoD Science and Technology Program.

I don't believe that we should be the spokesmen for your programs alone. I do believe that in setting the environment, we have to represent you to Congress in a manner that you can't, in addition to the way you represent yourself. We have to represent you to OMB in a manner that you can't, and again, that means in addition to your own ways of so doing. We have to represent you as part of the DoD Science and Technology Program to the Secretary of Defense in the way that you can't.

In listening the last couple of days, I have become even more convinced that in this active role that we are taking, that one doesn't push the DoD Science and Technology Program simply by asking for more money or for more slots. We are not going to get more slots or exceptional treatment just because we are asking for it, without relating to any good reason other than, if we don't get them, it will change our manner of operating. We are going to be asking for them only on the basis of a substantive program and the manner in which it is going to be hurt if we don't have more dollars, and more people, and more importantly, a different mix of people. I think it is only in terms of tying what a loss of super grades or GS-13's to 15's means to the DoD Science and Technology Program, that we feel comfortable in being spokesmen for you.

That was one of the main reasons for the emphasis on trying to see what that DoD Science and Technology was and what it meant to you. We are interested in whether you were able to help us relate how you wanted to participate in it, whether you were comfortable with it, whether you were able to relate to it, and your real honest problems in terms of personnel, ceilings, administrative activities to how it would negatively affect our DoD Science and Technology Program, unless we could resolve those issues.

I didn't get a lot of answers, but I didn't expect to, either, because we were meeting each other for the first time. You have to sort of decide whether or not you are going to trust somebody. You have to establish a rapport. I consider this meeting sort of a first step of what I hope is a courtship that results in a better interaction and relationship than we have had in the past.

First of all we are going to publish the results and we are going to send them back to you. We are going to put down the suggested actions that resulted from this meeting. After I get that feedback from you I intend to use this as a document, to talk to Bill Perry, and the Assistant Secretaries for R&D. They meet once a month on a Monday, and I am going to get on that schedule just as soon as we have something that you all have fed back to us and okayed. Then, we are going to try to phase that in a set of specific suggestions, and also to tie it down from the point of view of my office, into the rationale for some new ways that we are going to be operating in R&AT.

We are not going to be a spokesman for service programs and I don't think we should be. We want to be a spokesman for how the DoD S & T Program matches the stated DoD objectives as announced by the Secretary of Defense, the three service secretaries, as concurred in by Congress, and as understood by the Administration. Our goal then, is not to simply decide that we have work going on, and we have a good tri-service program in a given area, and the cooperation is adequate because all three services have a good information exchange. Our goal is going to be to see whether that DoD S & T Program matches stated DoD goals. Now, whether or not it does right now, I don't know. I can give you a number of examples where I know it doesn't.

For example, we don't have an all weather capability. Without an all weather capability, we can't fight in these kinds of environments. If we can't fight in these kinds of environments, the particular combat requirements that you have in NATO are unable to be met, Mr. Secretary. And it is that which I think is the responsibility of our office and not what we perhaps have been doing in the past, which is repeating what you tell us about your programs.

I believe very strongly, that we must be the spokesman to OMB for a uniform approach within the Department. OMB is our problem when it comes to administrative functions, and the concerns you have with A-76, A-109, A-17, A-21. With the reorganization in OSD, Bill Perry has all the resources, other than manpower, in the generic sense. We do want to be the spokesman to OMB for you in that regard. We haven't been yet in a coherent manner, because we haven't got the communications between you and us set up, and neither have we got the communications between our office and OMB, but we are doing that at the moment with A-76. You have already done it with A-109. That takes a bit of time for us to get set up. I am not so much concerned whether we have somebody entitled, laboratory management person, or whether we have all of us working in a task force that hits particular problems.

In terms of other administrative kinds of actions, I am on record in the Congressional Statement this year, saying that we would do something along the lines of Project Reflex. But I don't think the last Project Reflex showed anything. I think it showed everything you wanted it to and showed nothing at the same time. It wasn't a controlled experiment. There were no criteria by which to judge it at the OSD level. There wasn't any indication of how, if it was successful, to see what the ramifications were in other parts of the RDT&E community and what we wanted to do at OMB.

I have talked to both Congressman Ichord and his staff and have agreed that we will be working with laboratory directors, not to have an experiment, but to develop a means of providing more decentralized control to laboratory directors through eliminating many of the intercepting constraints. You can't have fiscal, manpower, programmatic and organizational constraints imposed on you all at once. So, I think Project Reflex should be entirely different than that which it was before. The goals of decentralized management in providing the responsibility for his program to the laboratory directors is what I think both Congressman Ichord and we are talking about when we use the phrase "Project Reflex" now as opposed to whatever it meant eight or nine years ago.

The other activity in which my office is going to be more active is in relationships and interaction with Congress, again, not as spokesman for your program, but as spokesman for the DoD S & T Program and how it matches with the DoD stated objectives. I say documentation is not the answer; you could provide as much documentation and as little to Congress, and it is neither going to win you a war or lose you a battle. What is very much important is getting to Congress those people in the DoD S & T community that can address the particular area of interest to Congress, address it well, and being willing and able to understand, with the help of my office, how that particular program is so essential to DoD's mission. That is what infrastructure means; it means what technological foundation that we are providing in the DoD S & T Program to the Department of Defense's stated goals. If we can't show that the structure of our program matches those goals, I see no reason for a DoD S & T program. Fortunately, I know we are, and we are going to a better job in the future. But that is really the job of my office, to show that we are pushing the scientific and techincal foundation, that we do have in place the scientific and technical infrastructure that can justify every element, every portion of the DoD S & T Program that we are supporting.

The last comment I would like to make is that I have learned a tremendous lot from this meeting. I still have a lot more to learn. I am delighted with the number of invitations I have picked up to visit you. I will be there, snow and rain permitting. I want very much to continue this kind of interaction. It replaces nothing that is already in place; that would be terrible. I think those of you that work with my staff have marvelous interactions. I don't know that we need 71 people all together again, but I would very much like to have that comfortable feeling of knowing that,

as we blow the whistle, there is a train behind us, or more importantly, that we are the engine at the end of the train helping to push the train go forward. In other words, I would like very much to be able to make sure that you have direct and allowable communications on the DoD S & T Program and all of its attendant problems, whether they be administrative, fiscal, or substantive. I would like you to know that we both can communicate with each other in those areas. This meeting was our attempt to start that communication process and to give it a little bit more push than it has had in the past.

I am very pleased with the result. I think it was great, and I refuse to let any of you convince me otherwise. So, I thank you very much for coming, and I hope that you will let me stay convinced of my feeling of accomplishment as of 3:00 this afternoon.

Good luck to you on your journey home, and we will see you real soon.

Congressman Ichord Reviews Role of In-House R&D Laboratories

As dinner speaker at the first DOD-wide Technical Laboratory Directors Conference, 24 July, Congressman Richard H. Ichord, chairman of the R&D Subcommittee of the House Armed Services Committee, reviewed output and role of in-house laboratories.

After recalling past in-house accomplishments such as the Sidewinder missile which introduced the birth of a whole new era of smart ordnance, and advances in electro-optical technology, he stated, "People in general tend to be less interested in hearing about how good you were or are, but are most interested in what you can do for them now."

In giving his reasons for sustaining in-house R&D, Congressman Ichord said it is imperative for the government to have a strong in-house technical arm that can be a "smart buyer," and work in a cooperative way with industry, the military, and the academic world to give us the best military hardware and technology at the least practical cost.

Secondly, he stated, the laboratories are needed to conduct R&D in those areas where there is little or no incentive for industry because of the lack of a major commercial market.

He went on to say that the in-house labs also provide technical options and viable alternatives that preclude unwarranted sole source procurements, and can provide the kind of quick-response capability that is frequently required in time of crisis.

"I cannot imagine a Department of Defense without a strong, viable, in-house laboratory system that can work with the academic, industrial and military communities to enhance the military capability of this country. The laboratories are here to stay," he stated.

Congressman Ichord hit on the "image problem" the Civil Service faces today, which he tied-in with the "not invented here" syndrome that the in-house laboratory system suffers.

"Industry on the one hand accuses you of locking out their concepts because they may compete with an in-house idea or system, you, on the other hand, tend to accuse the industrial complex of wanting to peddle their products in a way that will maximize their profit . . . .

"Both industry and the in-house activities have, from time to time, been guilty of these allegations, and I might add that the sooner you learn to work in a cooperative manner with industry, and they with you, the sooner the best interests of the defense of this country will be served . . . .

"My view is that with few exceptions, we must continue to rely on industry as the major source for the production of military hardware. Consequently, I don't believe that it is either desirable or practical to establish major production facilities within the in-house complex."

The Congressman, now serving his 9th term in the U.S. House of Representatives, continued with his concern over the time it is taking to transition a weapon system from concept to deployment.

"Bureaucratic red tape," he said, "has taken us from the days of the 5-year development-to-development cycle that was used in the Hawk, Nike-Ajax, Polaris, and many other programs, to the current 10 or 20-year cycle that is required to give us the SAM-D, or what is now called the Patriot, the Aegis, and the manned strategic bomber that we still do not have . . . .

"While we have been studying and restudying the requirements and looking for ways to make our systems more austere, the Soviets have been deploying one system after another, and quite frankly, have wrested the lead from the United States in many, many areas of military technology and capability."

The Missouri Congressman then expressed his concern for the current acquisition process. "This year, my Subcommittee took an extensive look into the so-called new acquistion strategy—the OMB Circular A-109." (This magazine featured *Major Systems Acquisitions: A Discussion of the Application of OMB Circular No. A-109* in the May-June issue.)

"I am willing to give it a try because, frankly, something has to be done to improve the cycle. I think that a large part of the problem today has been caused by our allowing the system to run us, rather than the converse. I intend to closely watch and monitor A-109."

In discussing some specific ideas on how the in-house R&D system might be improved, Congressman Ichord stated that some serious consideration should be given to reinstituting Project Reflex.

"From what I have been able to learn about this experimental project that was conducted about seven or eight years ago, it was indeed a success. I like the idea because it places authority and *responsibility* squarely on the shoulders of you, the laboratory directors.

"To me, it sounds entirely plausible to have a contract with a laboratory to produce an agreed-upon level of work for a prescribed amount of money and leaving the means to accomplish the objectives to the man in charge.

"As a very desirable aside, we have a yardstick or a measure for evaluating the effectiveness of you, the director, and your subordinate managers. Under this system, we can reward competence and rid the system of ineptitude.

"I might add that if the present trend to move more and more of the laboratory decision-making back to Washington continues, we will within a very short period of time reach that point where technical directors can be replaced by an average clerical worker."

Hon. Richard H. Ichord
House Armed Services Committee
Chairman R&D Subcommittee

Congressman Ichord concluded his remarks by saying that we must recognize that we live in an age of transition and must learn to change with the times—to have an organization dynamic enough to meet the ever-changing structuring and restructuring of our defense establishment and policies.

"On this point, I hope that you don't interpret dynamic to mean the ability to reorganize, because quite frankly, I don't believe that reorganization is always the answer to solving a management problem.

"All too often, troubled organizations needlessly reorganize, which tends to only move, rather than solve, the problem. As former Defense Secretary Schlesinger once commented on a proposed Army reorganization, 'It appears to me as though we have the same monkeys in new trees.'

"Being dynamic in this contest in which I use the term means having the ability to accept change—a change in our acquistion strategy or policy—and in the face of this change, being willing and able to continue as an effective player in the Defense process no matter how difficult the path."

END

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